



Género *Alexandrium* caracteres taxonómicos

**(Énfasis en *A. catenella*,
A. ostenfeldii y *A. cf. tamarense*)**

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División de Investigación en Acuicultura

29 de agosto de 2012



Desarrollo

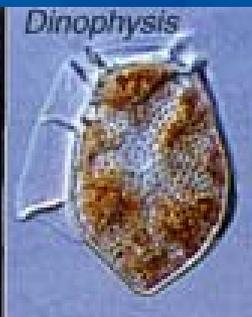
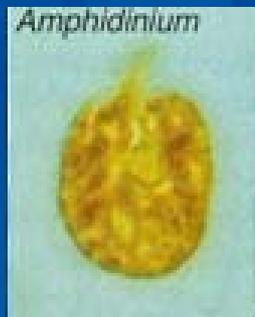
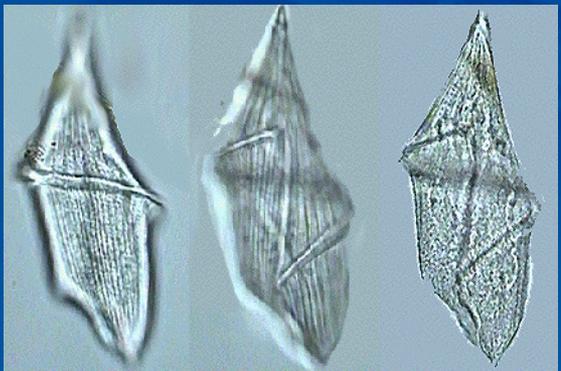
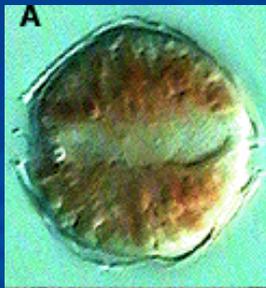
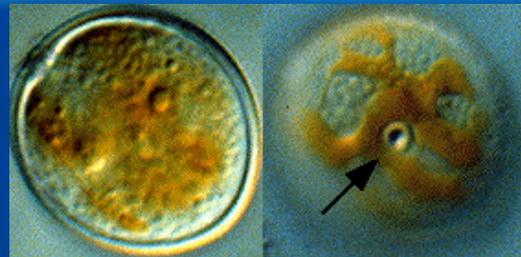
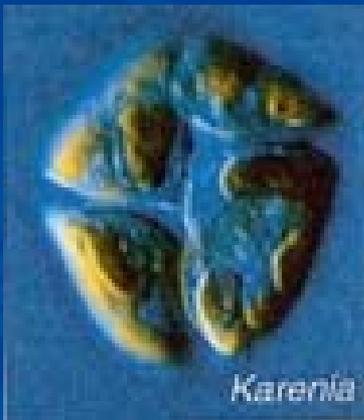
Características dinoflagelados

- Peridiniales vs. Gonyaulacales
- Género *Alexandrium*
- Especies de interés:
 - Características morfológicas - distribución mundial
 - Criterios para identificación en muestras del sur de Chile
- Registros de *A. cf. tamarense* en Los Lagos
- Metodologías para identificación especies
 - Epifluorescencia – Ventajas y costos

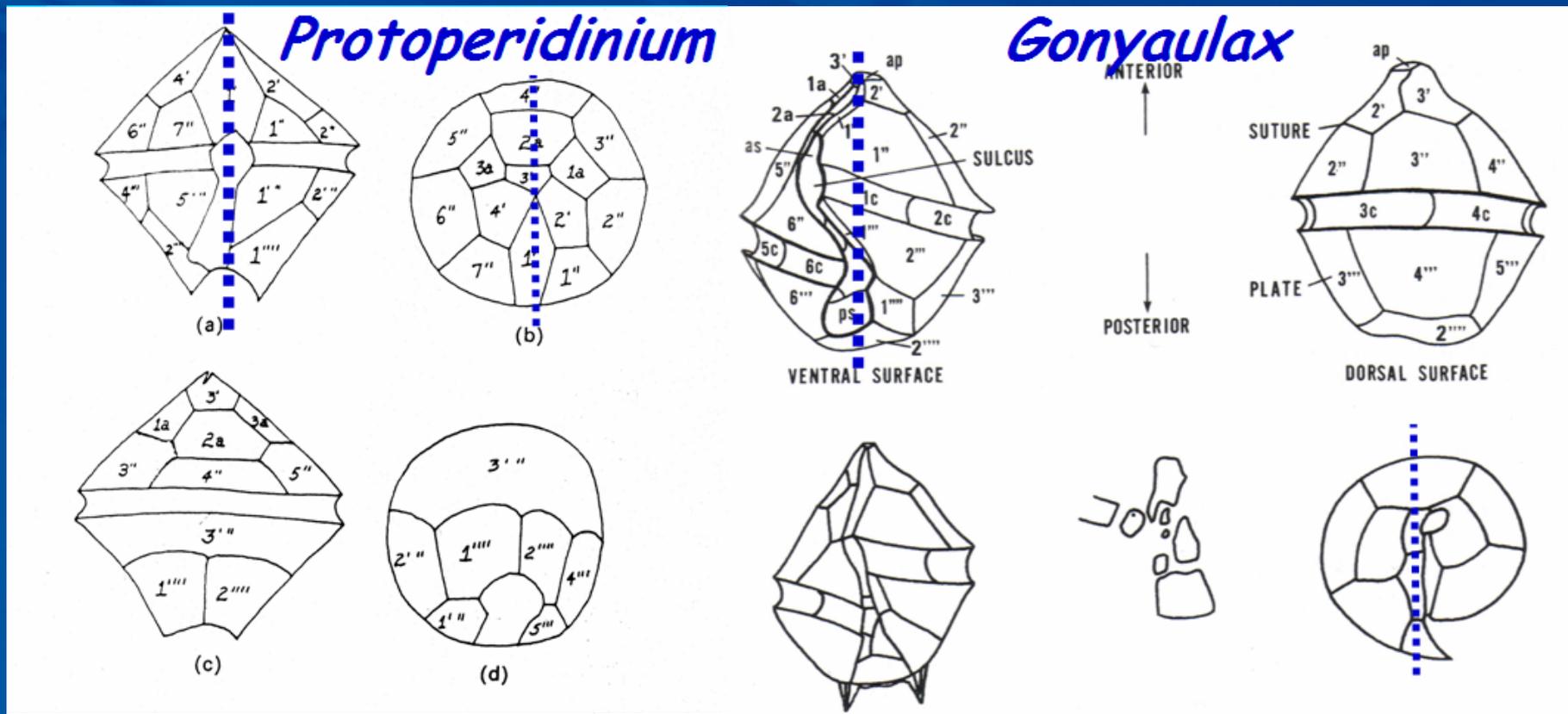


Características Dinoflagelados

- Pertenece junto a Protozoos ciliados y Apicomplexa al Grupo Alveolata
- División Dinophyta
 - ❑ Clase Dinophyceae
 - ✦ SubClase Peridiniphyceae
 - » Orden Gonyaulacales
 - Familia Gonyaulacaceae
 - » Orden Peridinales
 - Familia Protoperidiniaceae



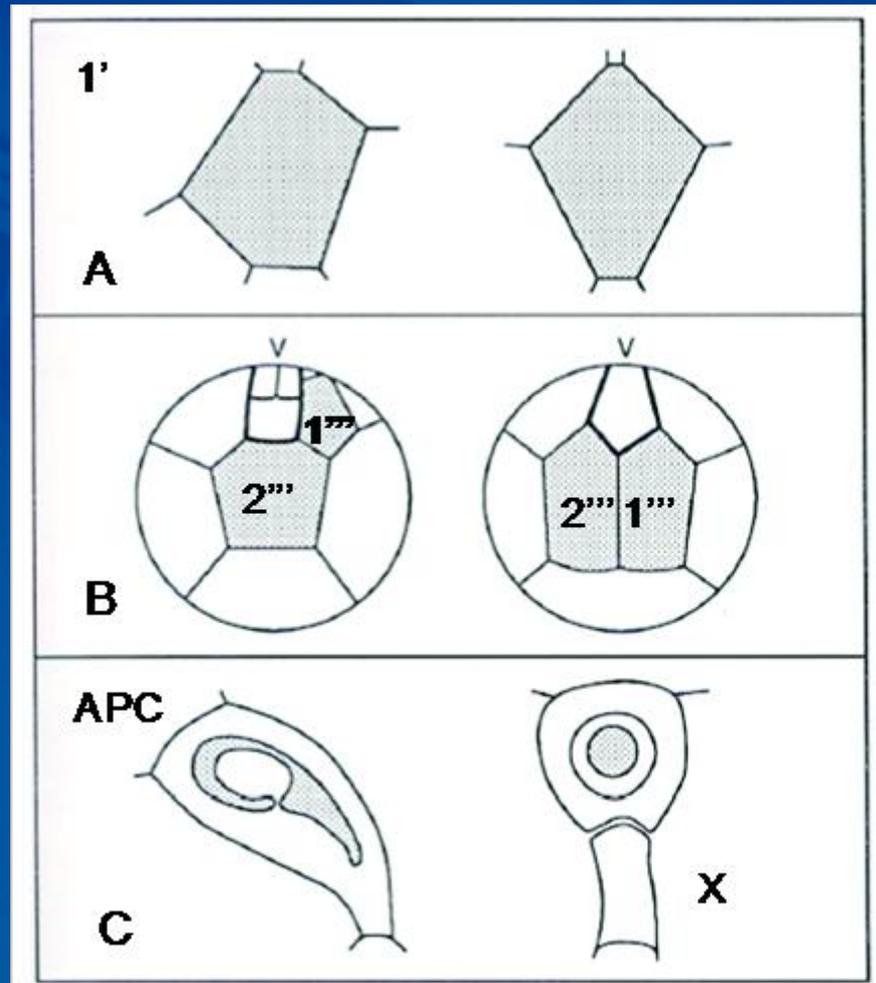
Peridinales vs. Gonyaulacales



Comparación morfología general entre peridinales y gonyaulacales

(Adaptado de Larsen, 2011)

Peridinales vs. Gonyaulacales

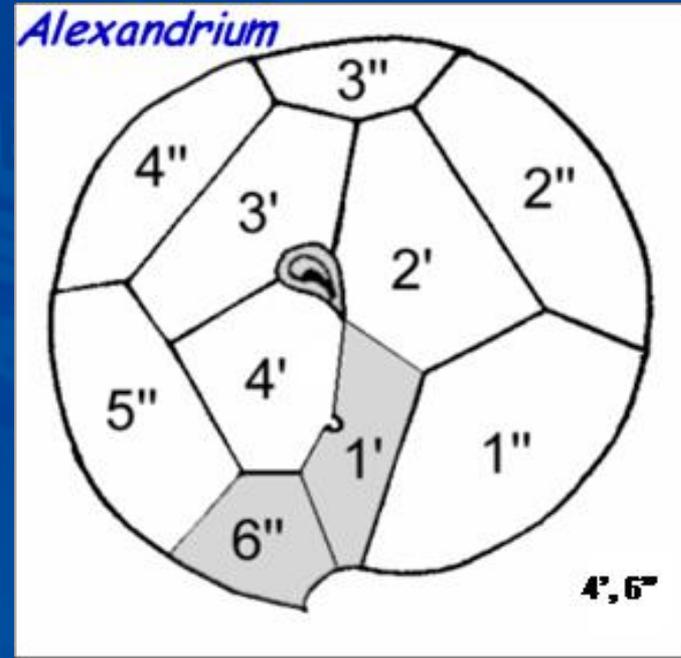
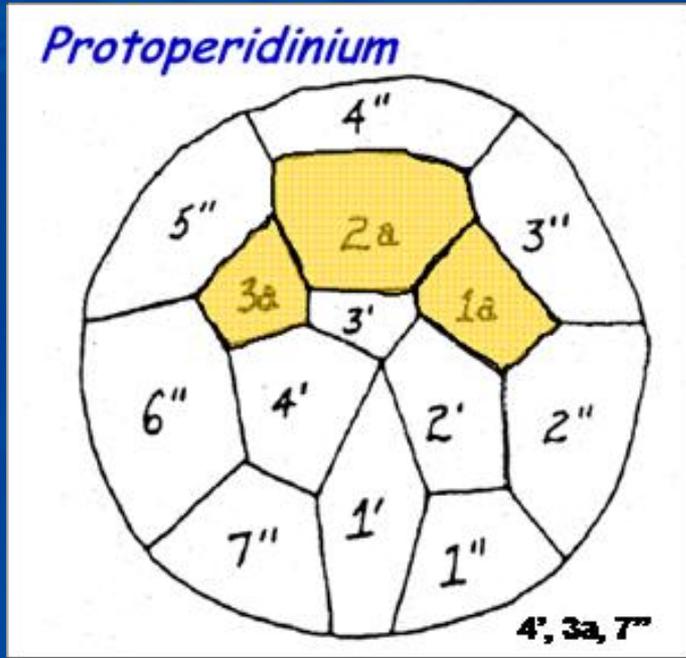


Principales diferencias entre las placas de peridinioides y gonyaulacoides

(Adaptado de Larsen, 2008)



Peridinales vs. Gonyaulacales

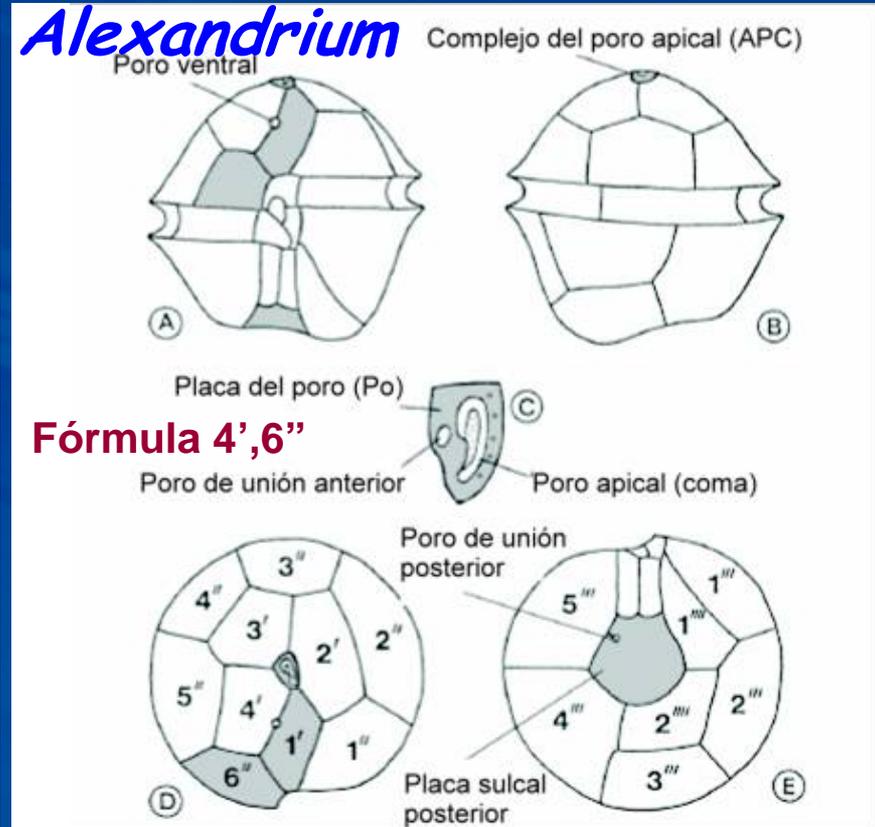
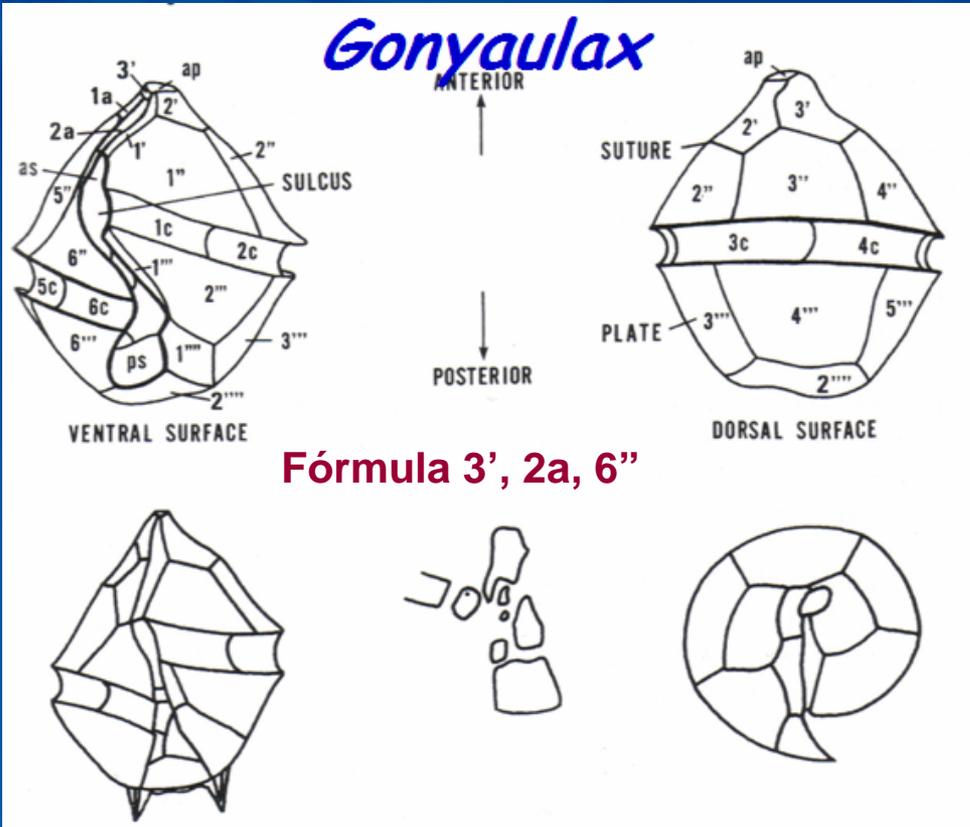


Tabulación apical de peridinales (*Protoperidinium*) y gonyaulacales (*Alexandrium*)
(Adaptado de Larsen, 2008)



Gonyaulacales

(*Gonyaulax* y *Alexandrium*)



Diferencias de tabulación entre *Gonyaulax* y *Alexandrium*

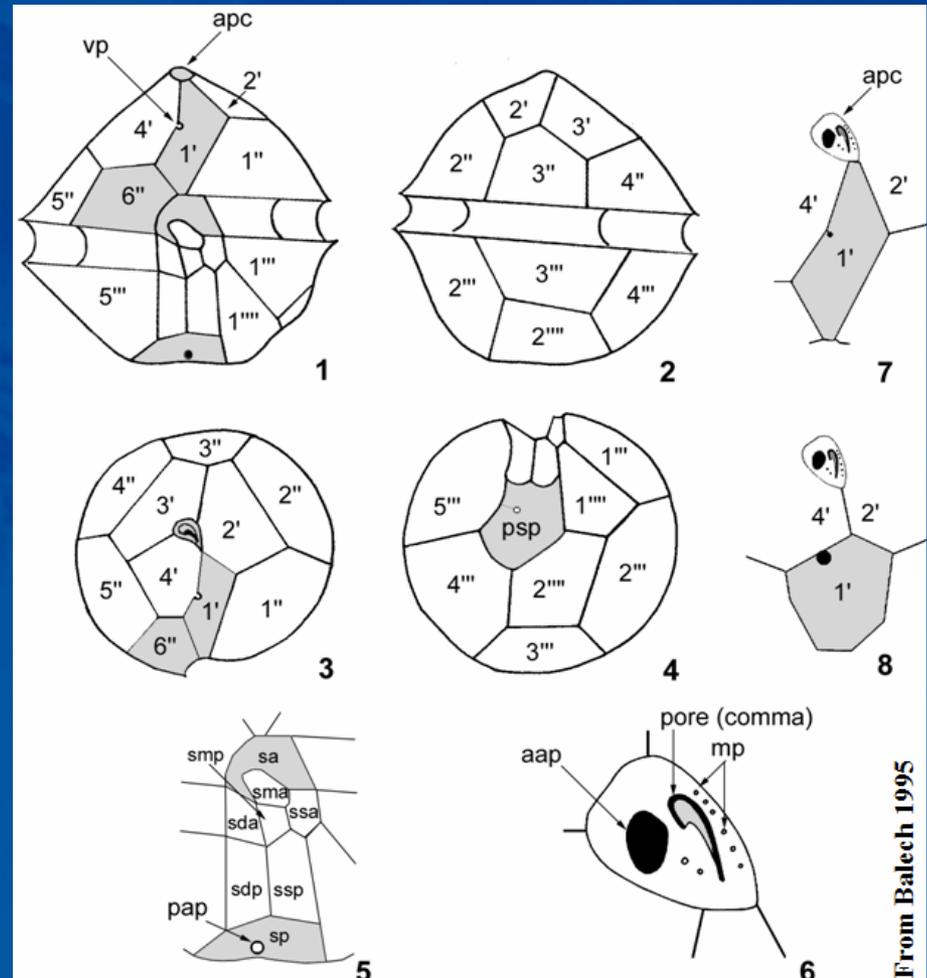
(Adaptado de Balech, 1995 y Larsen, 2011)

Gonyaulacales - *Alexandrium*



Características diagnósticas

- tamaño y forma
- 1' y 6''
- sa y sp
- APC



Arreglo de las placas en el género *Alexandrium*

(Adaptado de Balech, 1995 y Larsen, 2011)



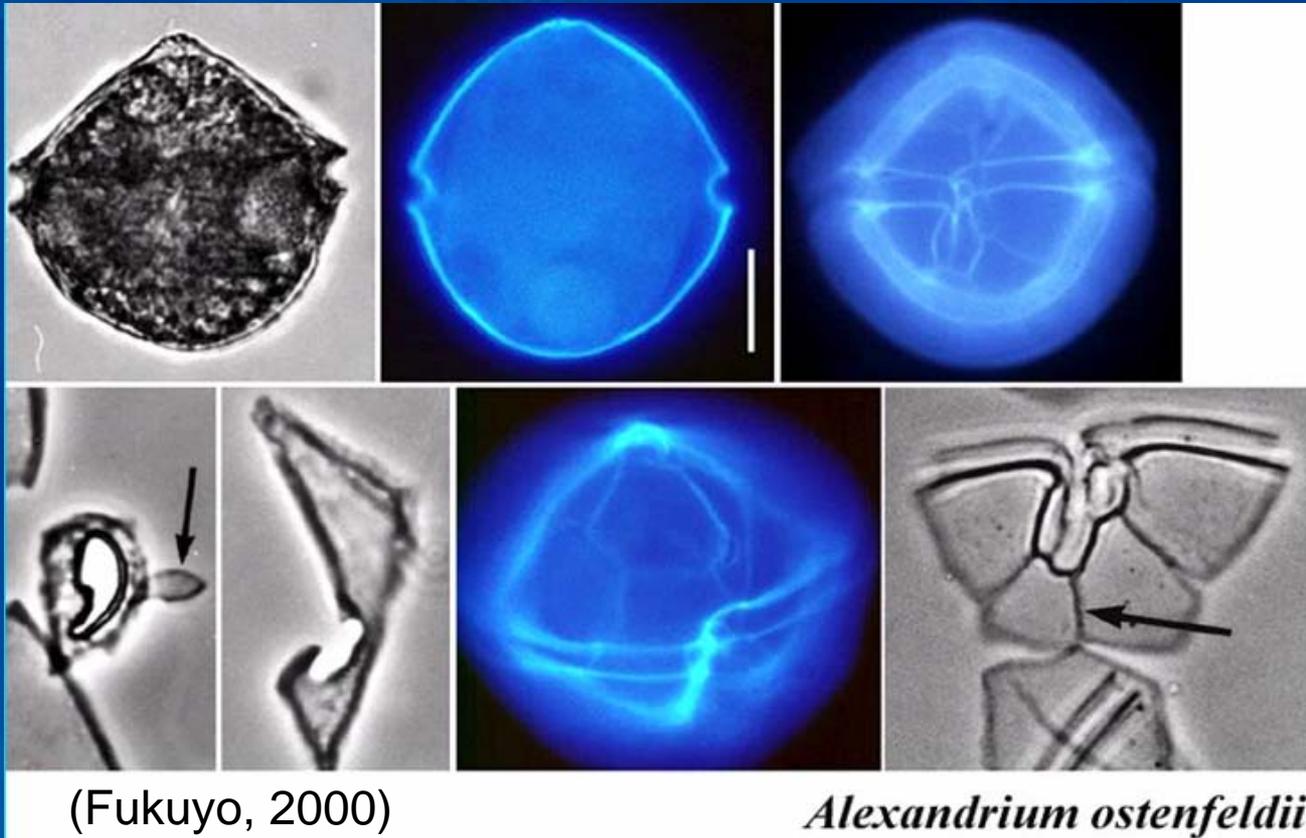
Género *Alexandrium* (Morfo-grupos)

- grupo *minutum*
- grupo *ostenfeldii*
- grupo *catenella*
- grupo *fraterculus*
- grupo *kutnerae*
- grupo *tamarense*
- subgénero *Gessnerium*



Género *Alexandrium* (grupo *ostenfeldii*)

1' angosta con poro ventral de gran tamaño, 2 sinónimos?
Especies: *A. ostenfeldii*, *A. peruvianum*



(<http://dinos.anesc.u-tokyo.ac.jp/Jpeg/Alexandrium/fra-tam-ost.-comp.jpg>)



Género *Alexandrium* (grupo *ostenfeldii*)



Distribución de *A. ostenfeldii*
(Adaptado de Larsen, 2008)



Género *Alexandrium* (grupo *ostenfeldii*)

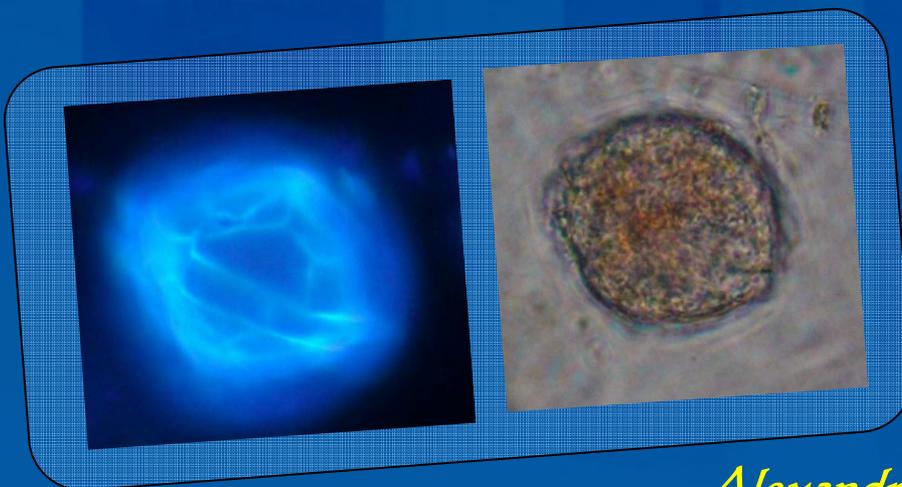
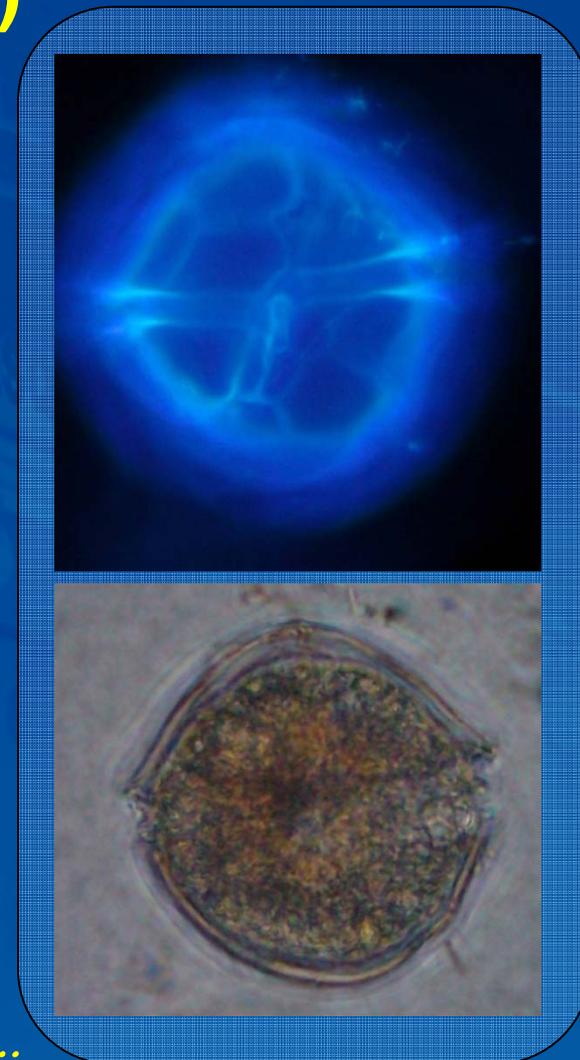
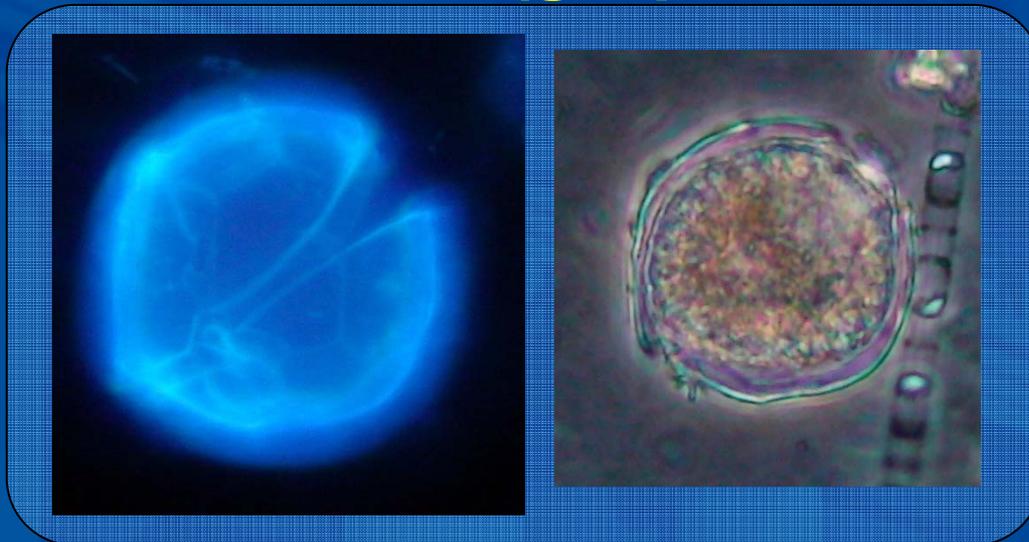


Distribución de *A. peruvianum*

(Adaptado de Fraga, 2007)



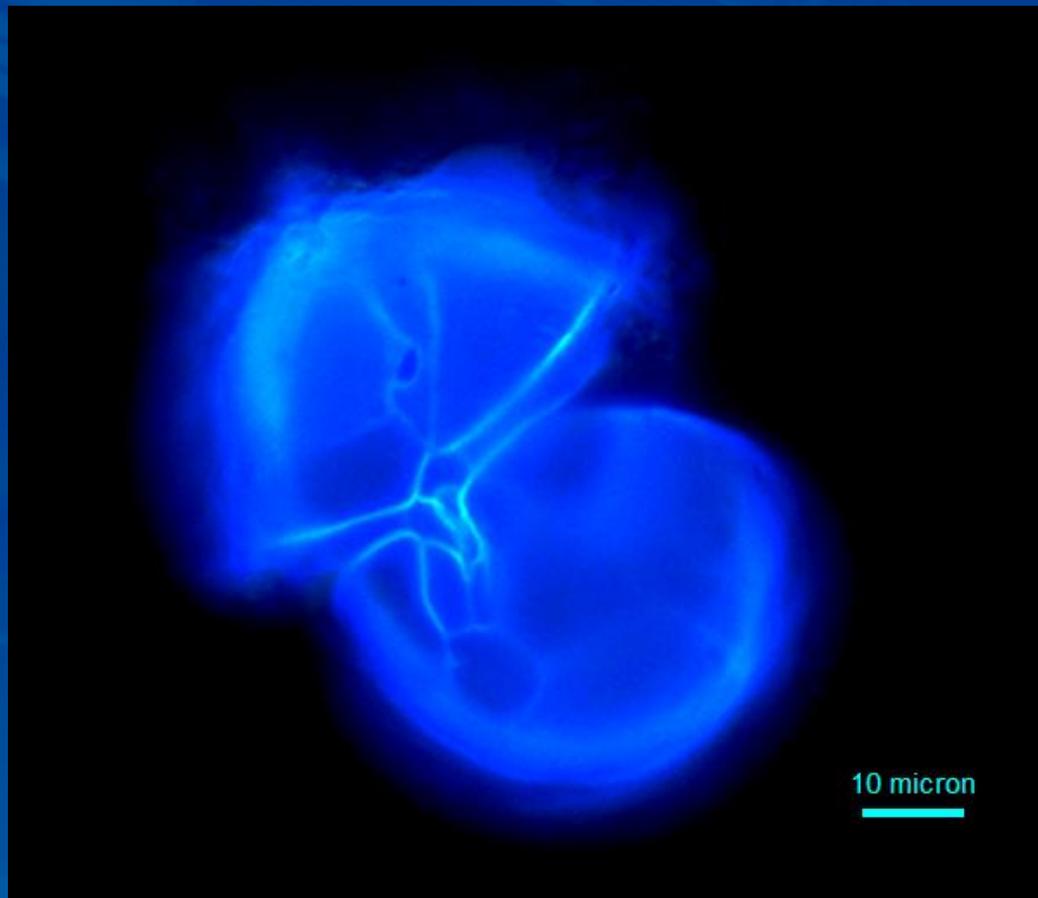
Género *Alexandrium* (grupo *ostenfeldii*)



Alexandrium ostenfeldii



Género *Alexandrium* (grupo *ostenfeldii*)

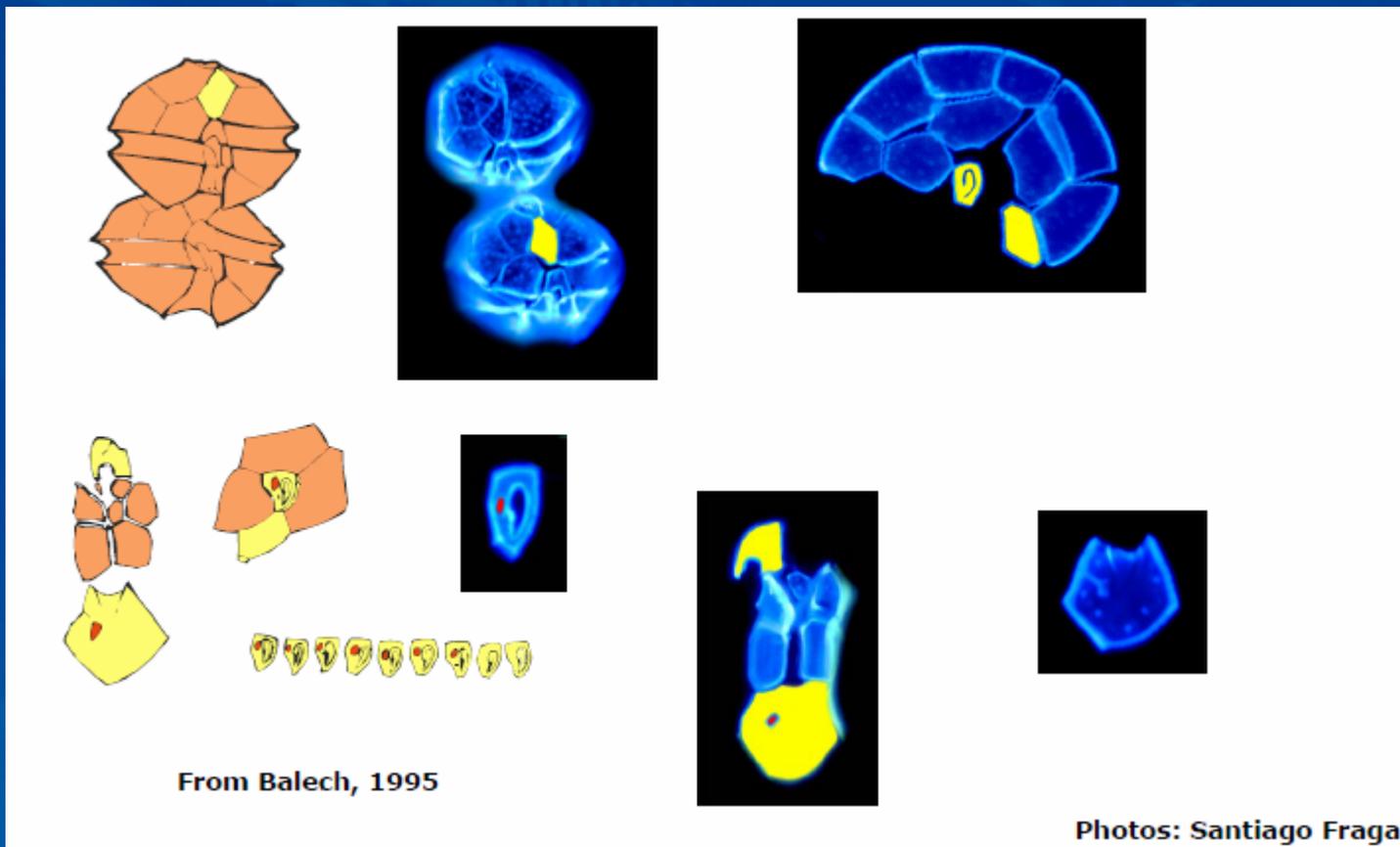


Detección de *A.ostenfeldii* desde año 2009 – inicio uso de epifluorescencia



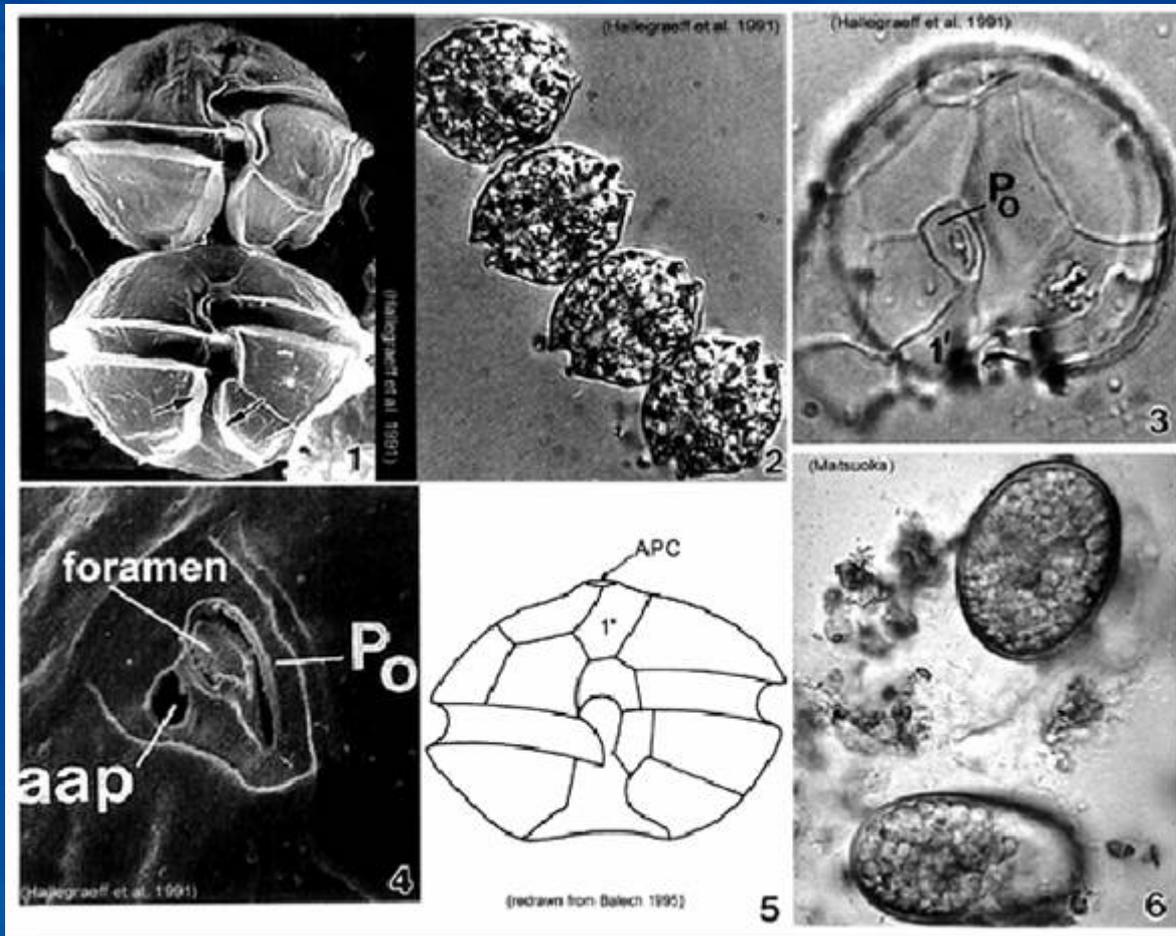
Género *Alexandrium* (grupo *catenella*)

Células comprimidas antero-posteriormente, formadoras de cadenas, poro ventral ausente. Especies: *A. catenella*, *A. compressum*





Género *Alexandrium* (grupo *catenella*)

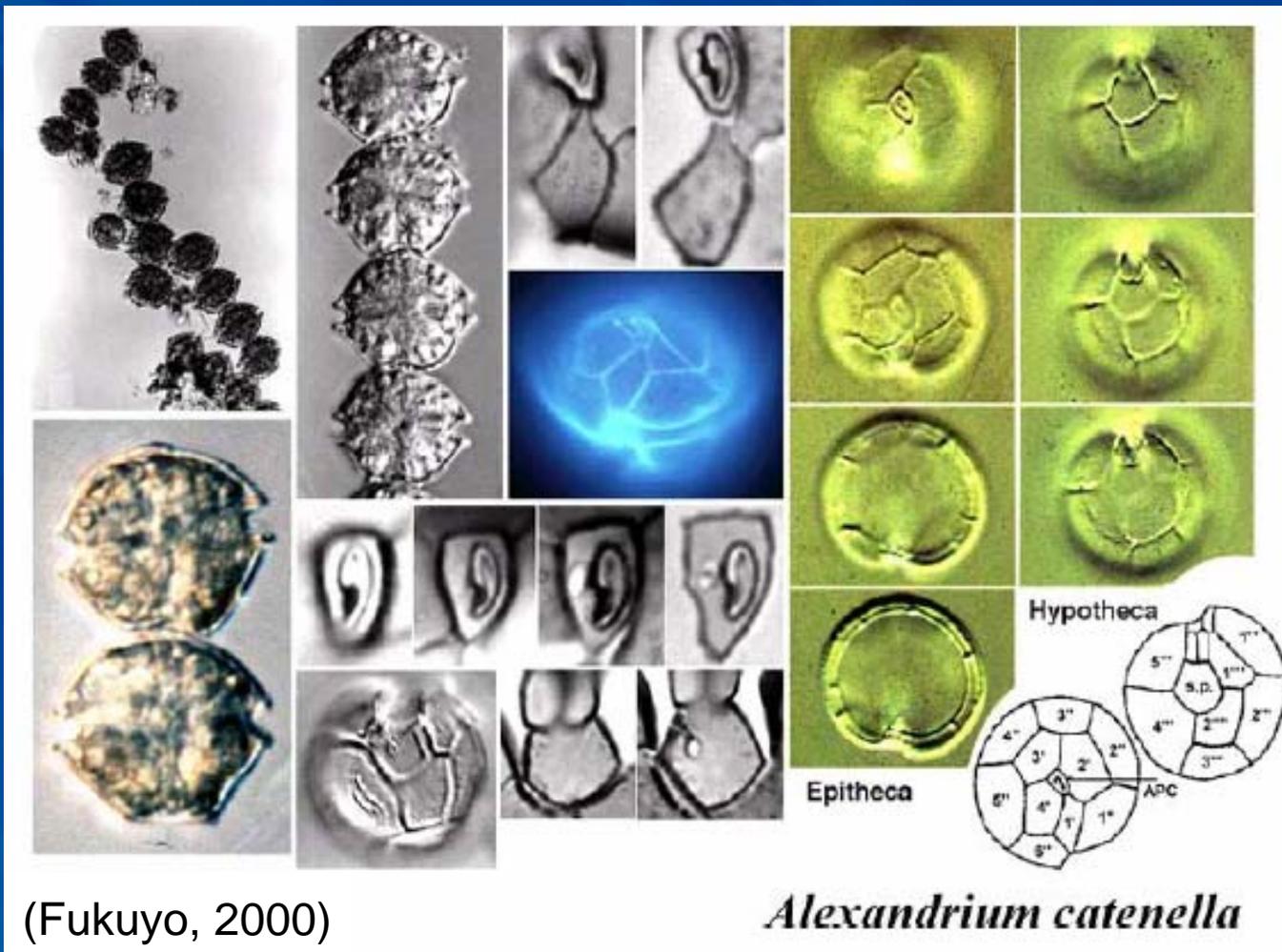


(Faust y Guedge, 2002)

<http://www.nmnh.si.edu/botany/projects/dinoflag/Taxa/Acatanella.htm>



Género *Alexandrium* (grupo *catenella*)



(Fukuyo, 2000)

Alexandrium catenella



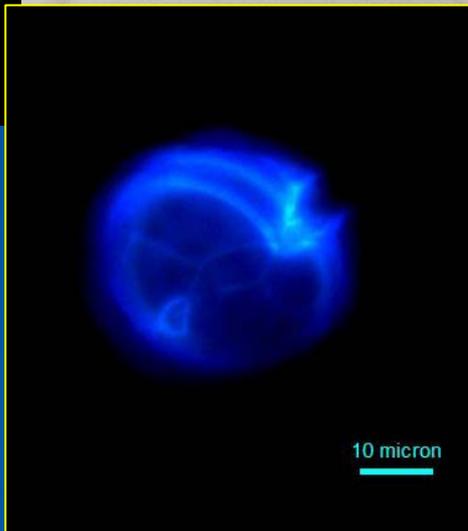
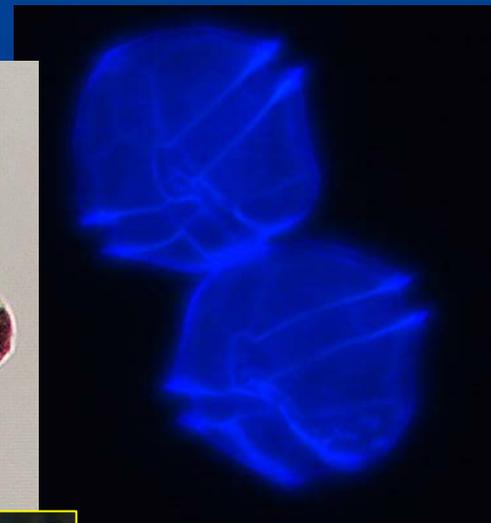
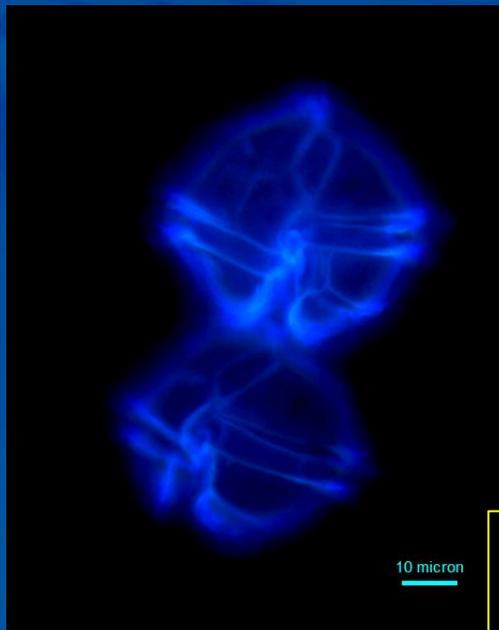
Género *Alexandrium* (grupo *catenella*)



Distribución de *A. catenella*
(Adaptado de Fraga, 2007)



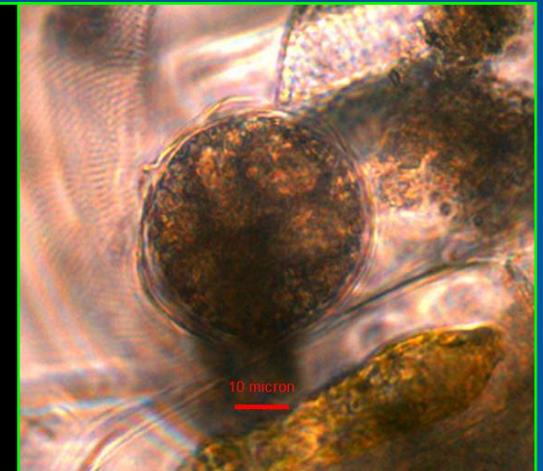
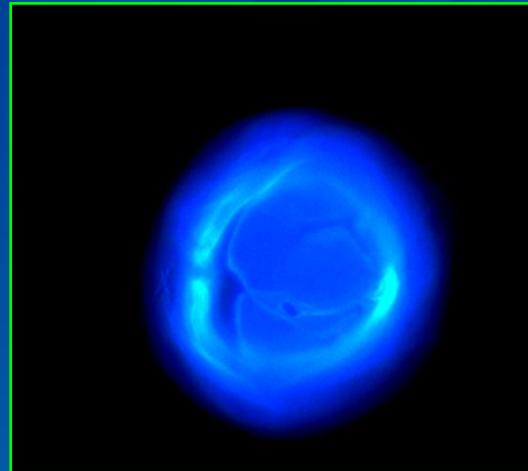
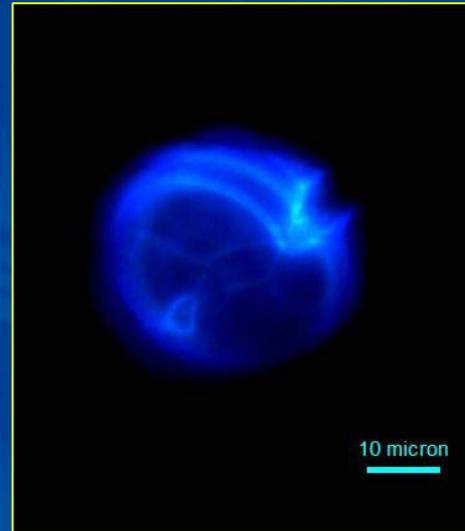
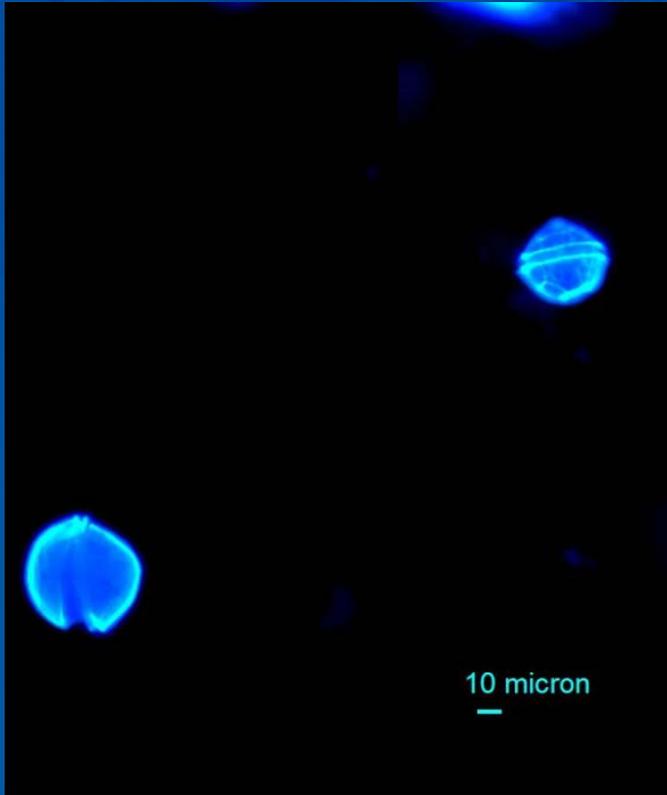
Género *Alexandrium* (grupo *catenella*)





Género *Alexandrium*

(comparación *A. ostenfeldii* y *A. catenella*)

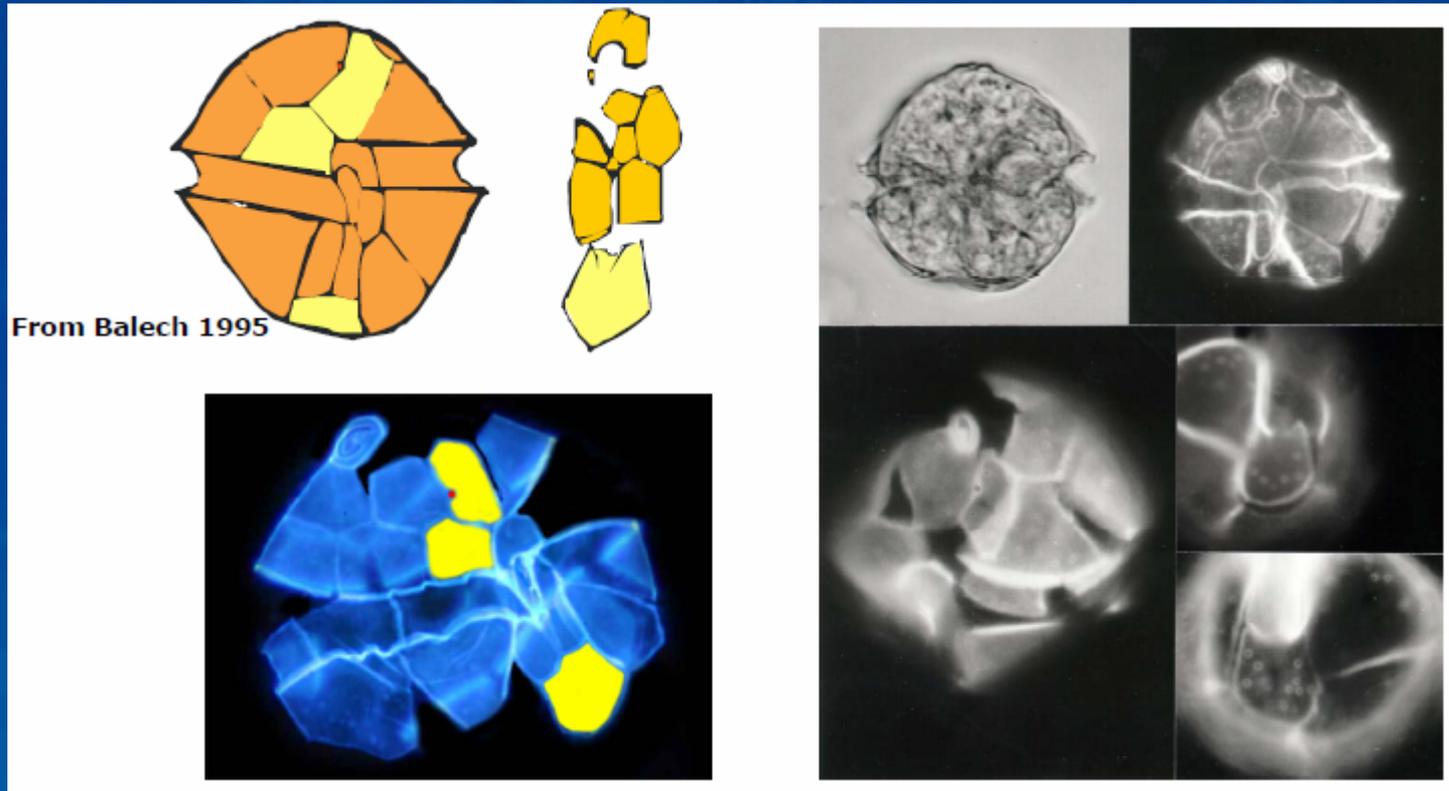




Género *Alexandrium* (grupo *tamarense*)

Difícil de definir morfológicamente, única característica en común podría ser la forma de la placa sp. Con o sin poro ventral.

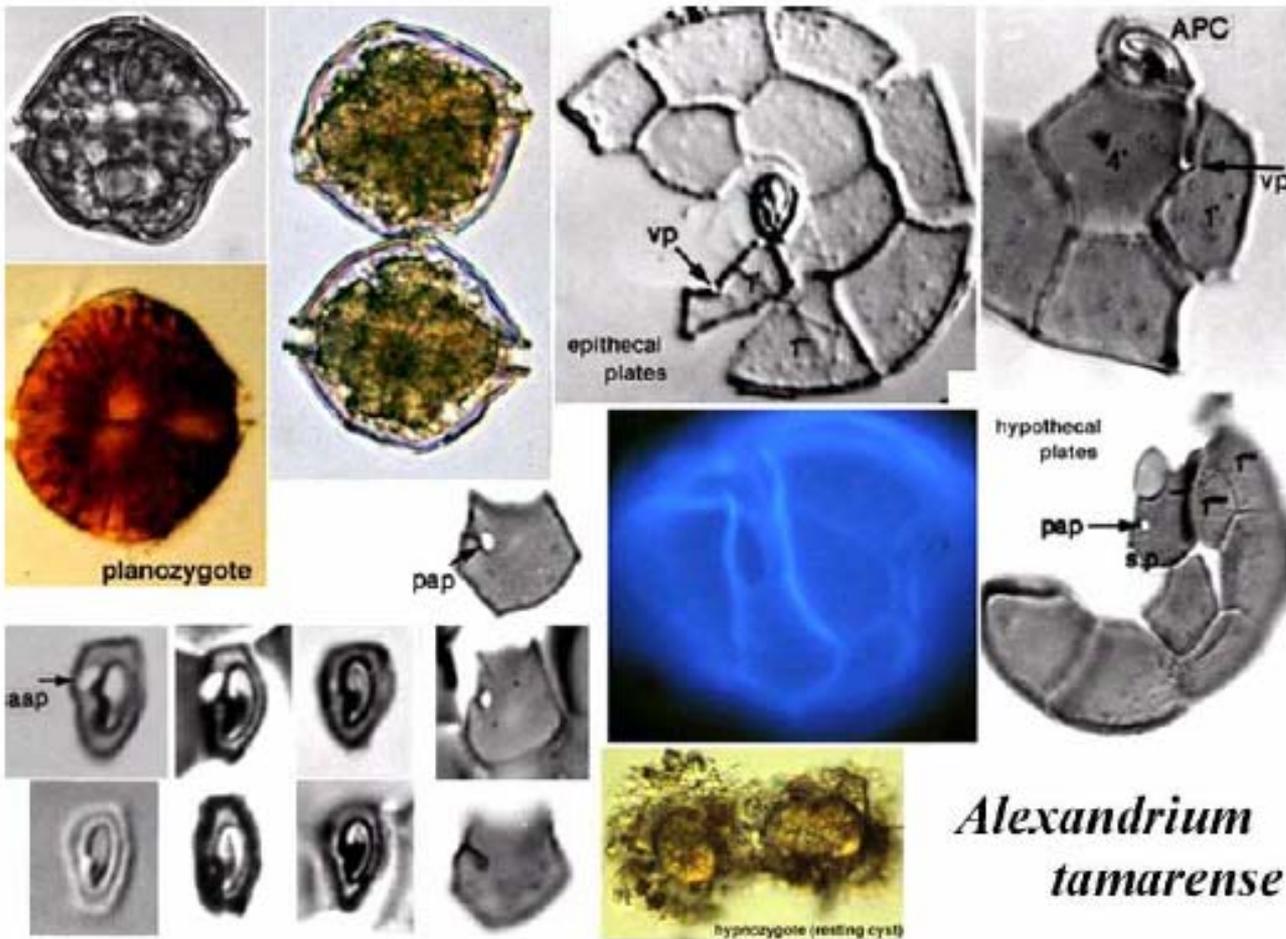
Especies: *A. tamarense*, *A. acatenella*, *A. fundyense*, *A. tropicale*



(Adaptado de Fraga, 2007)



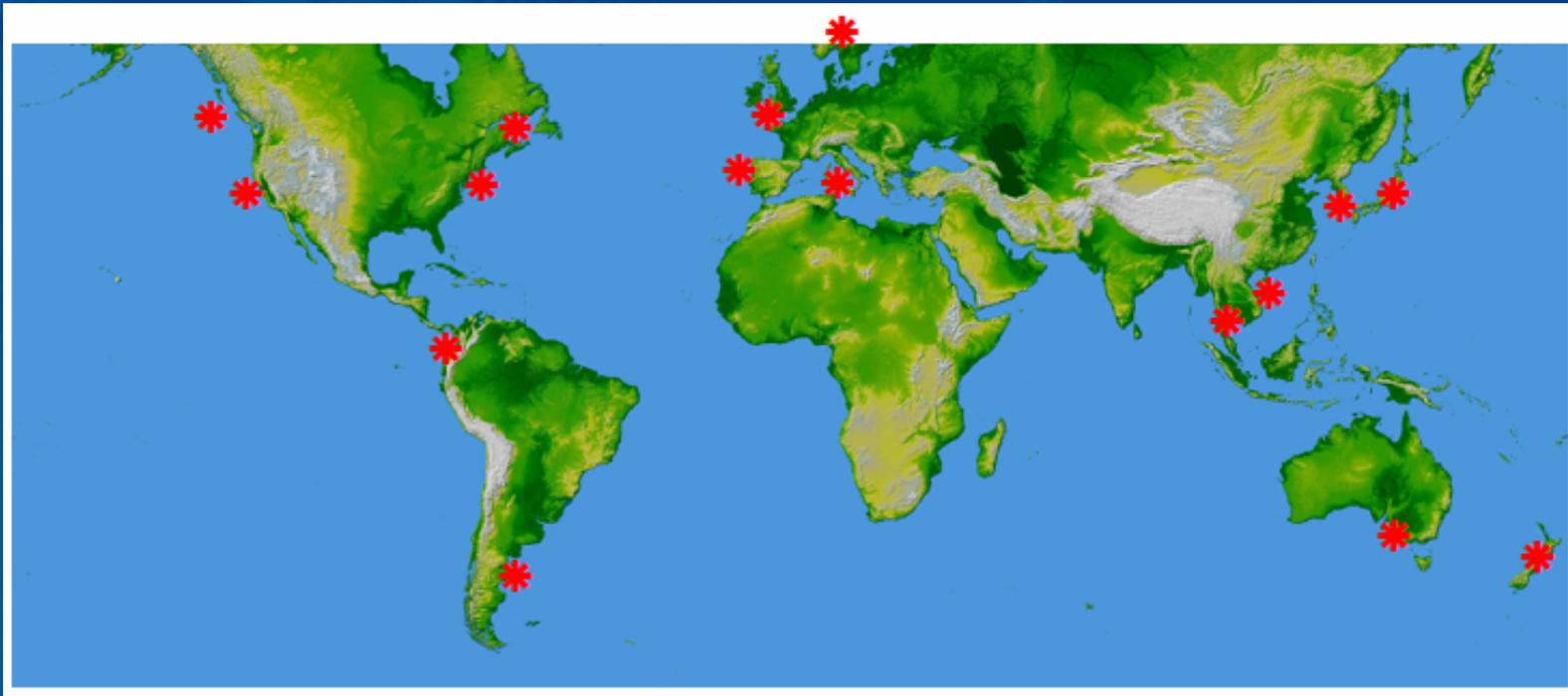
Género *Alexandrium* (grupo *tamarense*)



(Fukuyo, 2000)

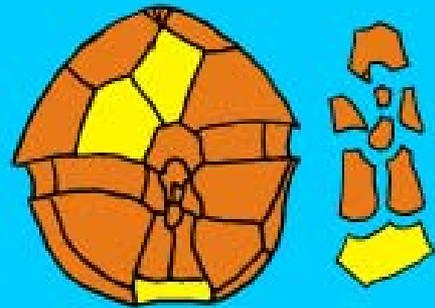
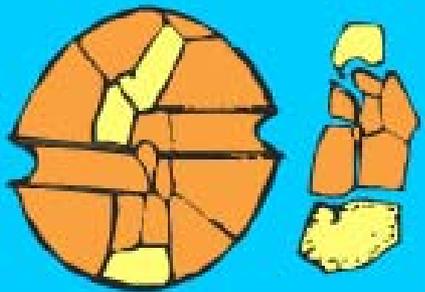
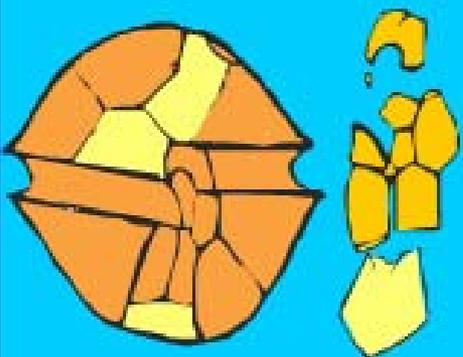
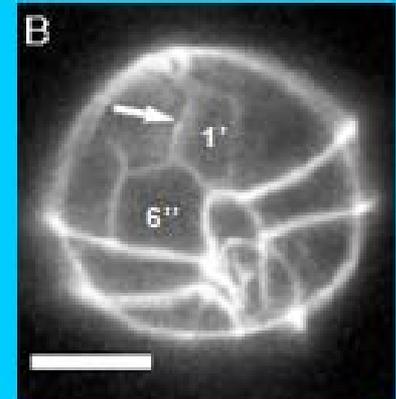
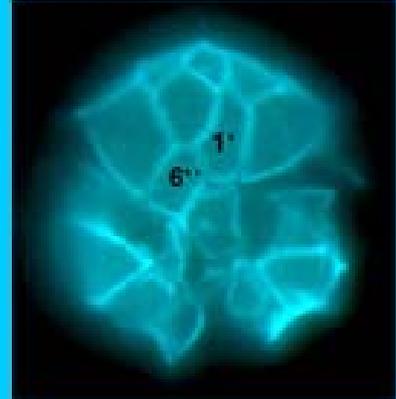
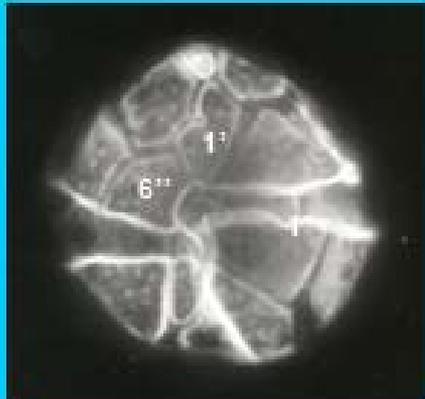


Género *Alexandrium* (grupo *tamarense*)



Distribución de *A. tamarense*
(Adaptado de Fraga, 2007)

Grupo *tamarense* ~ *minutum*



A. tamarense

A. minutum

A. tamutum

(Adaptado de Larsen, 2011)



Variabilidad intraespecífica *A. tamarensis*

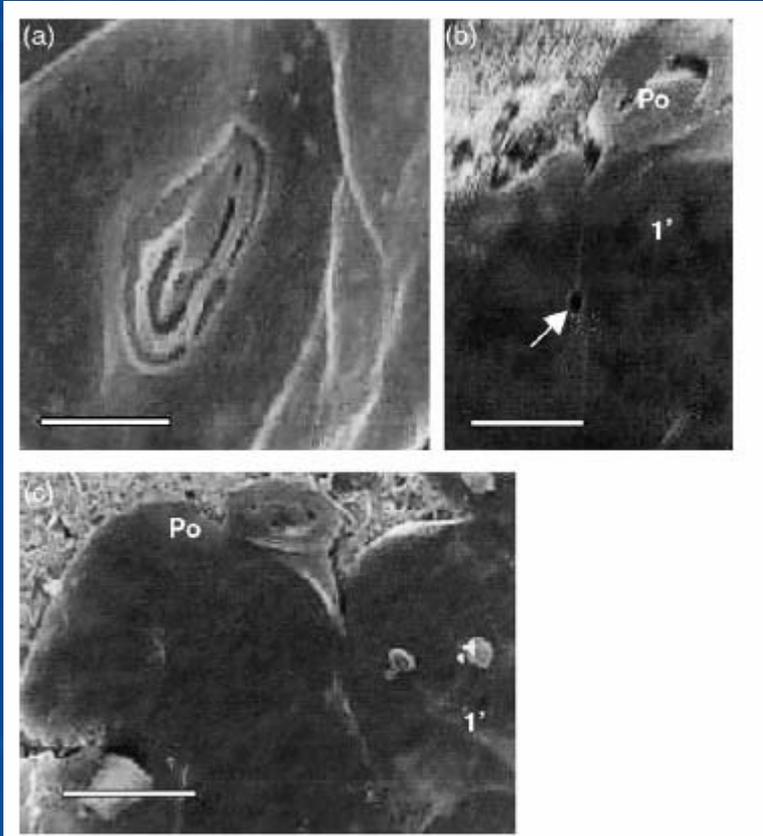


Fig. 2. Morphology of *A. tamarensis* from Golfo Nuevo. S.E.M., clone AT-3D: (a) detail of the apical pore scale bar = 2 μm ; (b) plate I_B with ventral pore (arrow); (c) plate I_B without ventral pore scale bars = 1 μm .

Table 1
Percentage of *A. tamarensis* cells with a ventral pore (% v.p.) in a field sample from Golfo Nuevo and in clones AT-3D and AT-2D cultured under different conditions

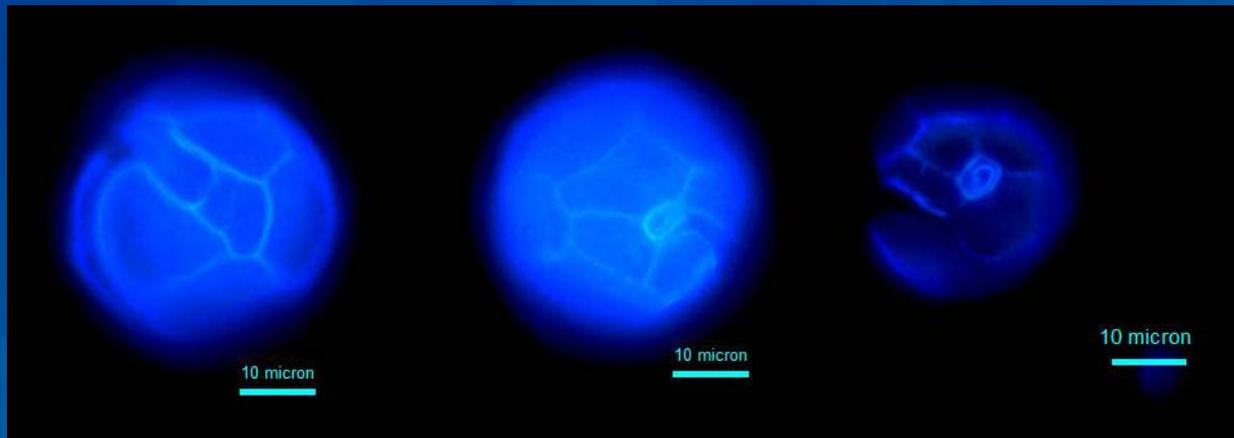
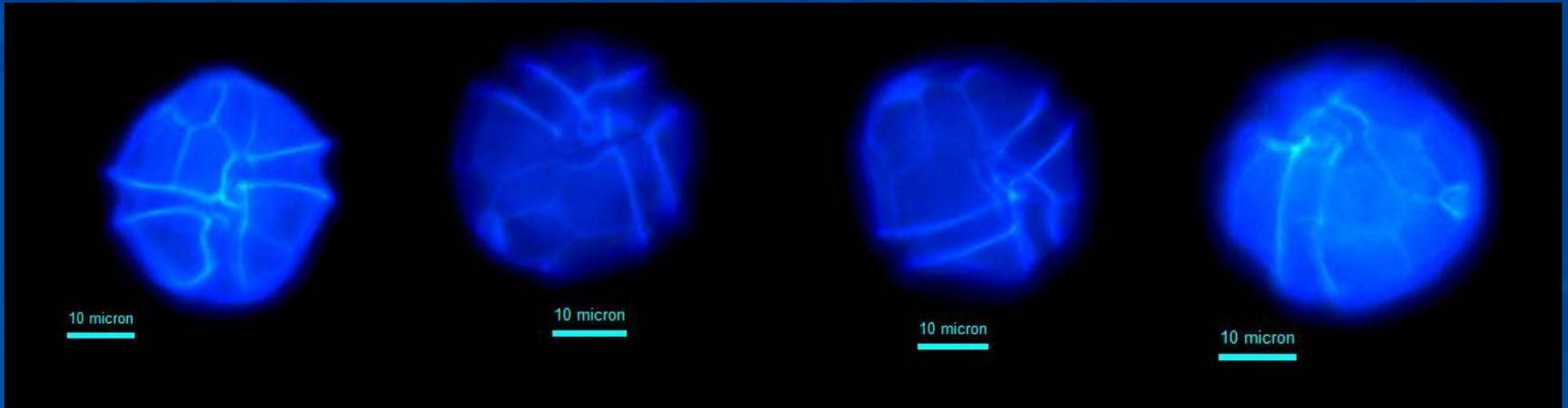
Samples	Temperature (°)	Irradiance ($\mu\text{mol m}^{-2} \text{s}^{-1}$)	% v.p.	n
Field sample	14		63	130
AT-3D clone	10	200	12	42
	10	80	40	20
	15	35	48	50
	20	80	42	100
	20	35	100	50
	20	200	50	50
AT-2D clone	10	35	72	100
	15	35	45	20

(Gayoso y Fulco, 2006)



Variabilidad intraespecífica

A. tamarense – cultivo Vigo





Variabilidad intraespecífica *A. catenella*

(Varela et al, 2012)

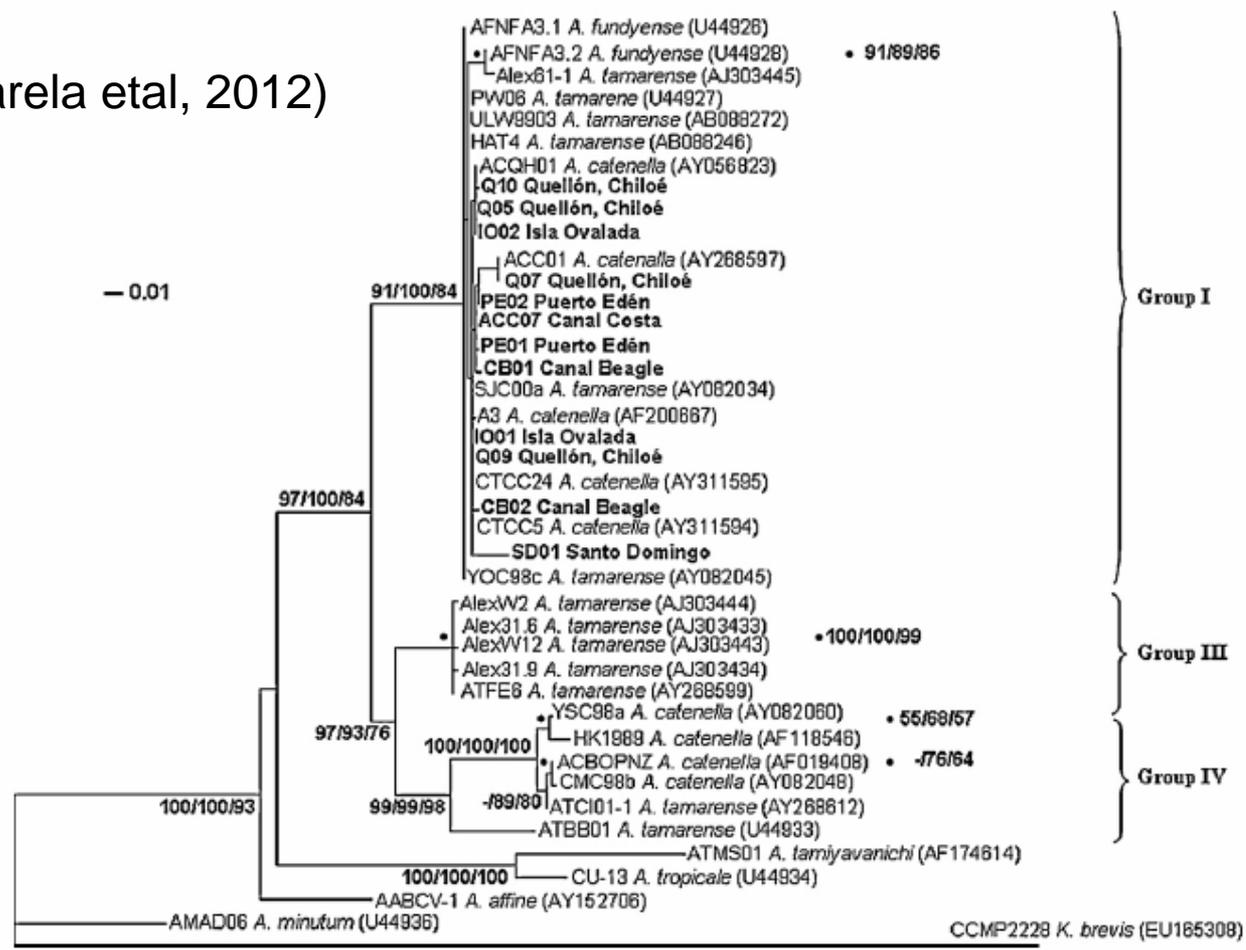


Fig. 4. Maximum likelihood phylogenetic tree derived from partial LSU rDNA (D1–D3) sequences of different *Alexandrium* species/strains closely related to the Chilean *A. catenella* isolates. Bootstrap support values for three phylogenetic approaches (NJ/MP/ML) are shown adjacent to the corresponding node. Dash (-) indicates bootstrap support less than 50%.



Relación tamarense - catenella

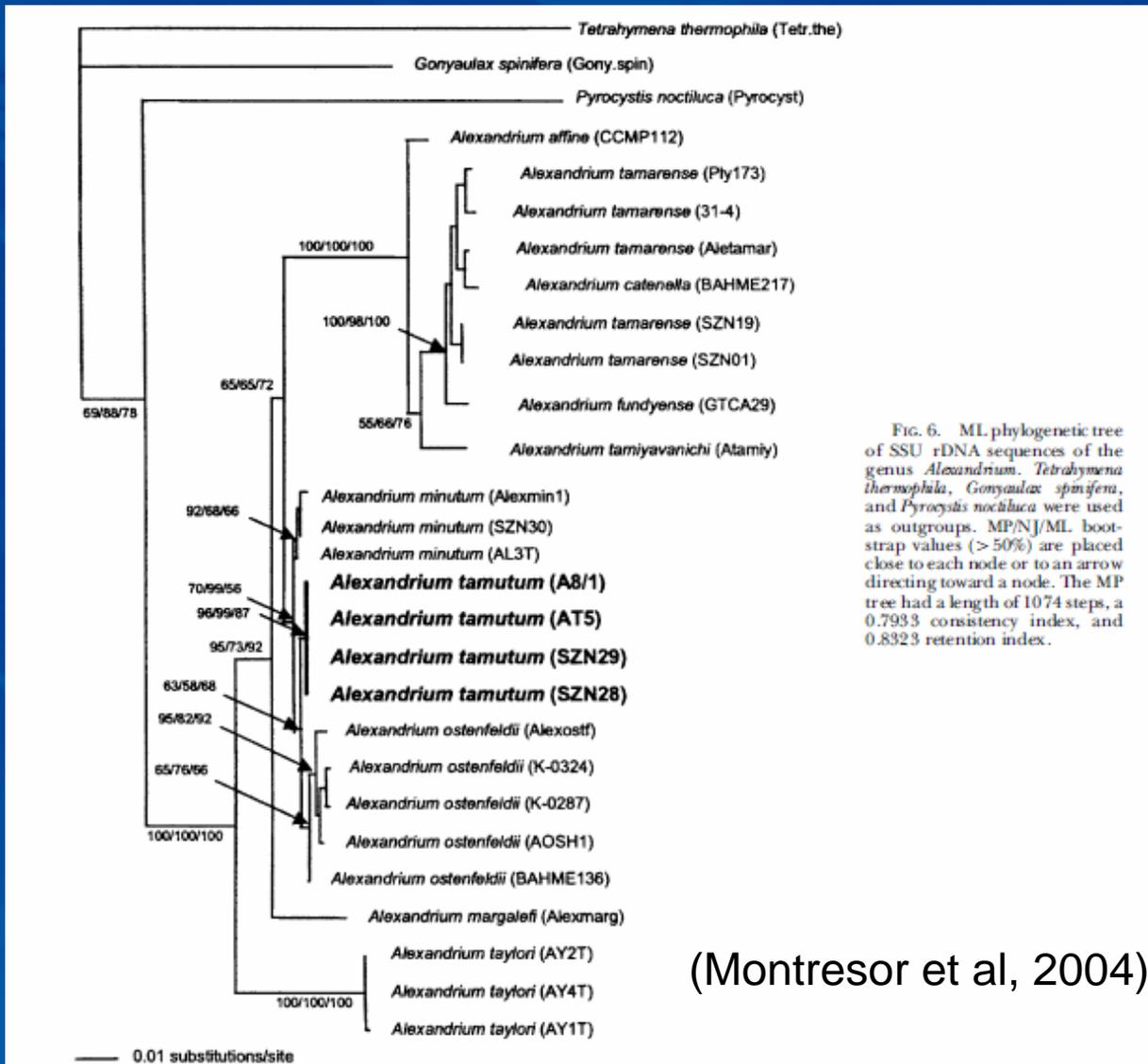
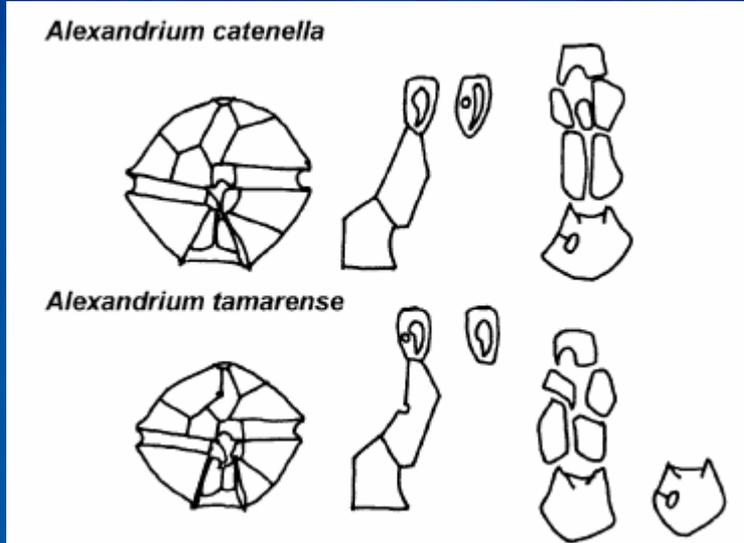


FIG. 6. ML phylogenetic tree of SSU rDNA sequences of the genus *Alexandrium*. *Tetrahymena thermophila*, *Gonyaulax spinifera*, and *Pyrocystis noctiluca* were used as outgroups. MP/NJ/ML bootstrap values (> 50%) are placed close to each node or to an arrow directing toward a node. The MP tree had a length of 1074 steps, a 0.7933 consistency index, and 0.8323 retention index.

(Montresor et al, 2004)



Relación tamarense - catenella



(MacKenzie et al, 2004)

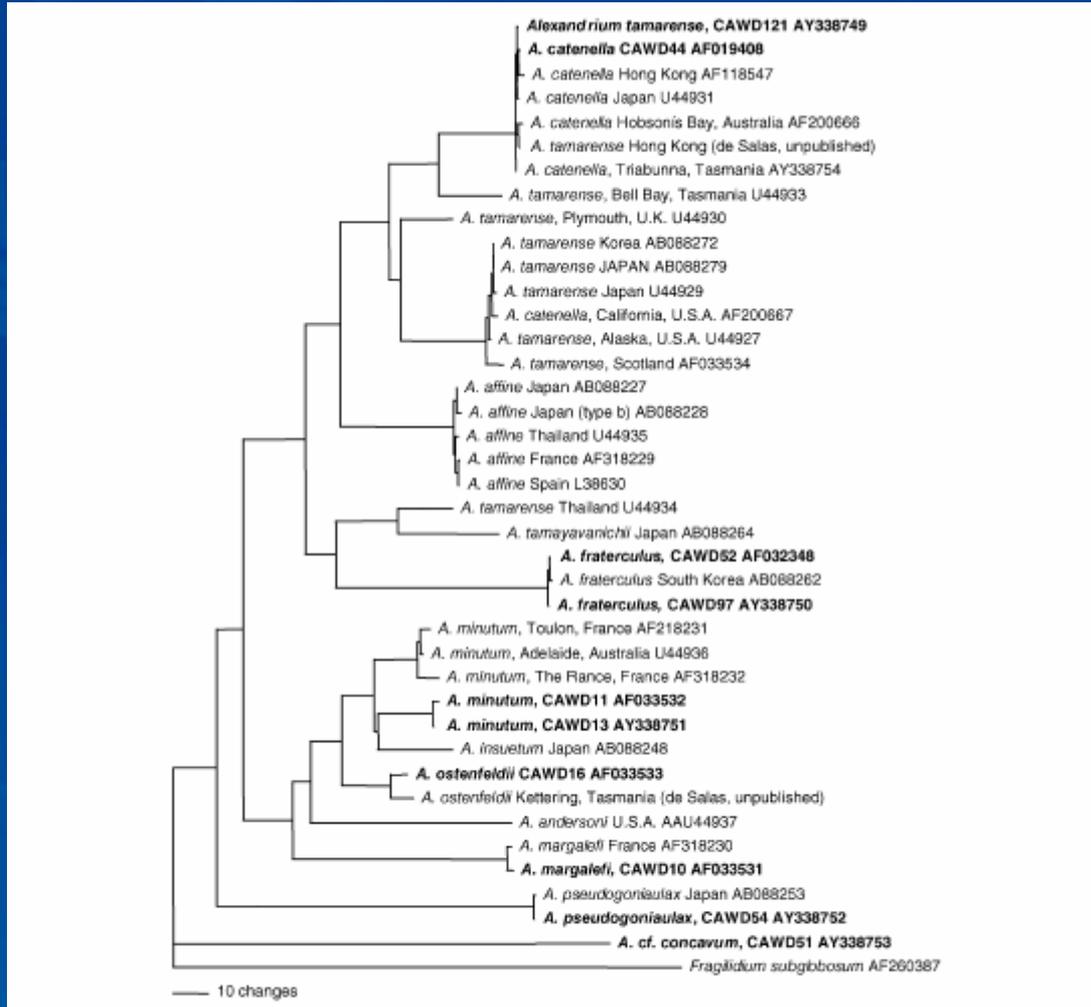
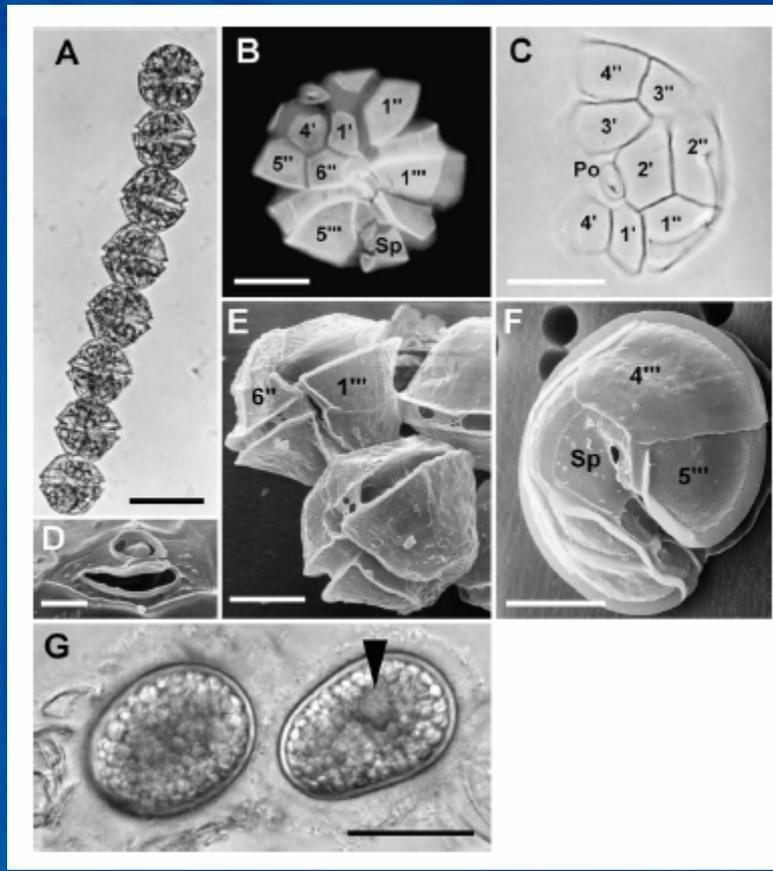


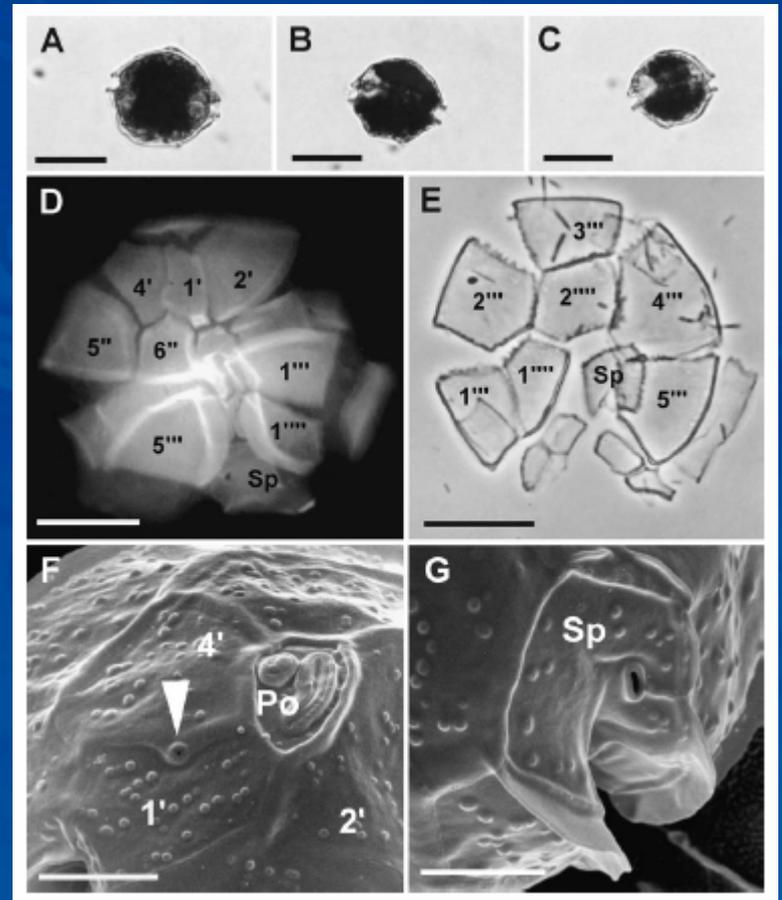
Fig. 13. Phylogenetic relationships, based on aligned D1-D2 LSU rDNA sequences, among *Alexandrium* species isolates from New Zealand and elsewhere. The neighbour joining tree was constructed using maximum parsimony as the search criterion. Distances are absolute, and names in bold were sequenced for this study. Accession numbers for GenBank sequences and the Cawthron culture collection designation are provided after the name.



Relación tamarense - catenella



A. catenella



A. tamarense

(MacKenzie et al, 2004)



Relación tamarense - catenella

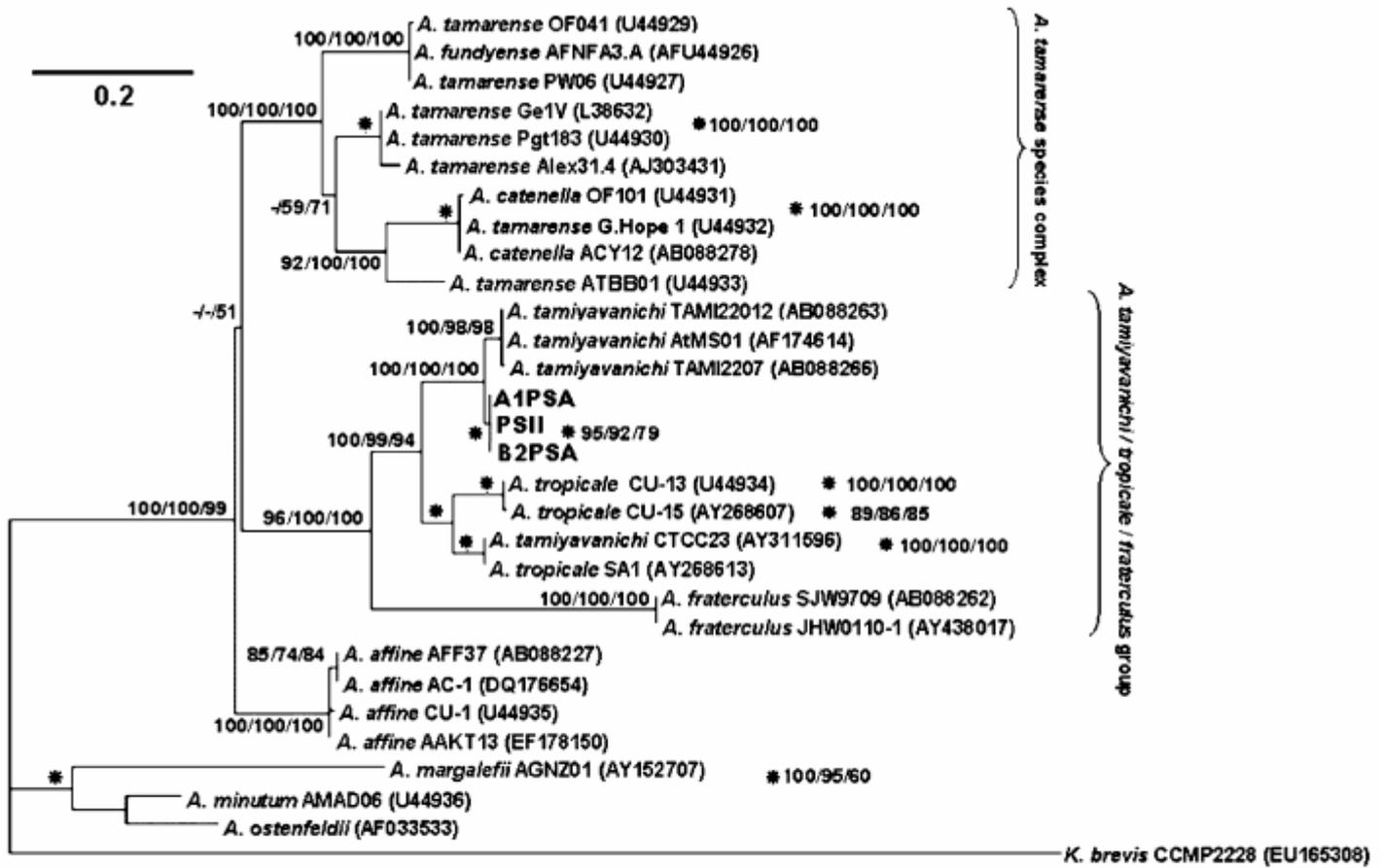


FIG. 5. Maximum-likelihood (ML) phylogenetic tree derived from partial LSU rDNA (D1–D2) sequences of different *Alexandrium* species/strains closely related to Brazilian *Alexandrium tamiyavanichi* isolates (A1PSA, B2PSA, and PSII). Bootstrap support values for three phylogenetic approaches (NJ/MP/ML) are shown adjacent to the correspondent node. Dash (-) indicates bootstrap support <50%. MP, maximum parsimony; NJ, neighbor joining.

(Menezes et al, 2010)

Relación tamarense - catenella

(Varela et al, 2012)

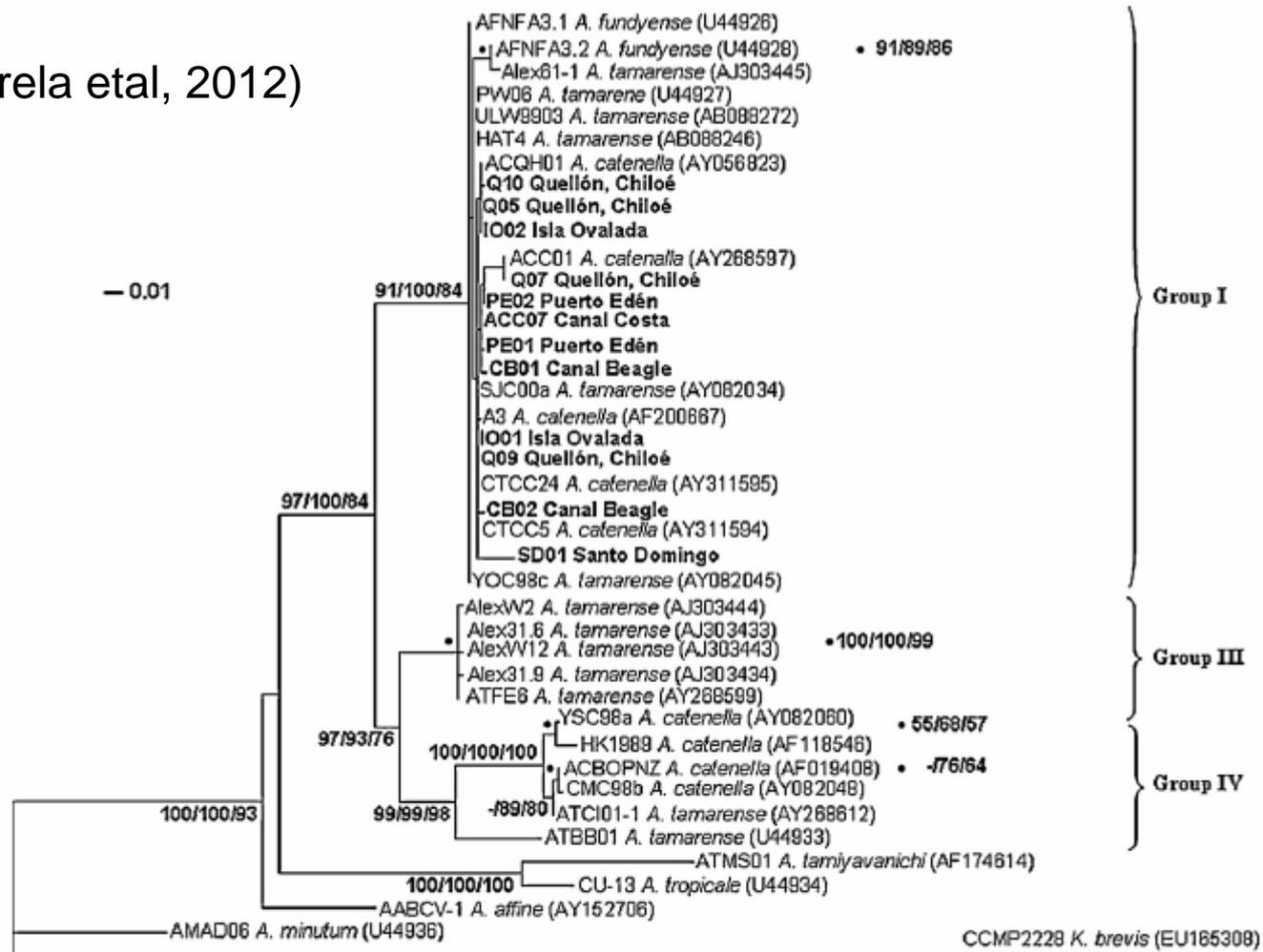


Fig. 4. Maximum likelihood phylogenetic tree derived from partial LSU rDNA (D1–D3) sequences of different *Alexandrium* species/strains closely related to the Chilean *A. catenella* isolates. Bootstrap support values for three phylogenetic approaches (NJ/MP/ML) are shown adjacent to the corresponding node. Dash (-) indicates bootstrap support less than 50%.



Relación tamarense - catenella

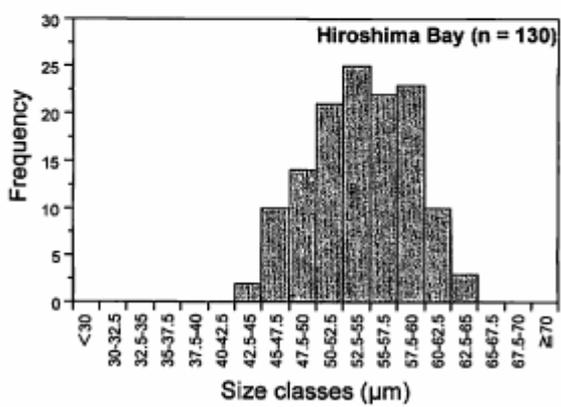
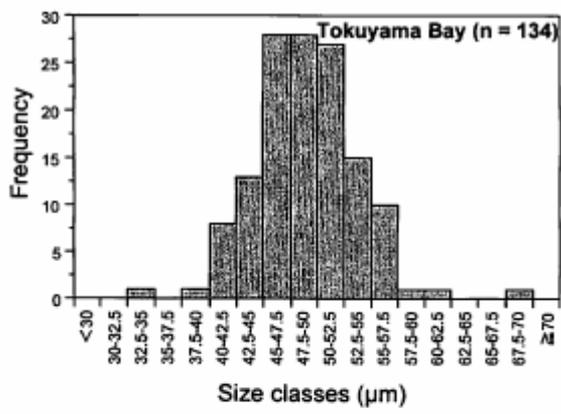


Fig. 2. Cyst length-frequency distributions of the naturally occurring *Alexandrium* cysts from Tokuyama Bay (upper) and Hiroshima Bay (lower).

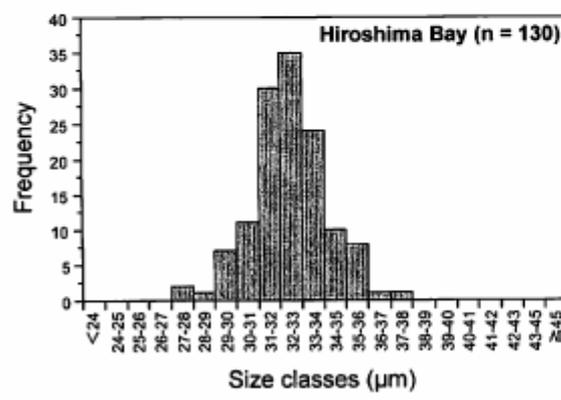
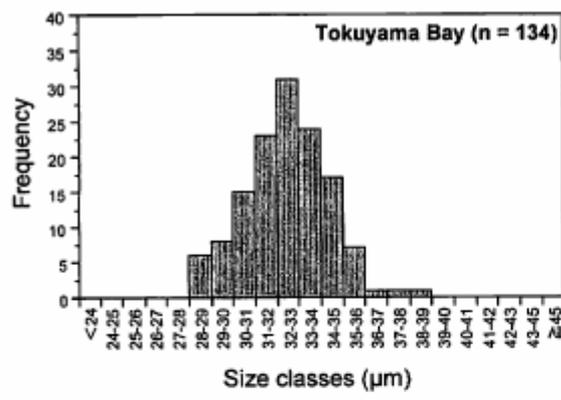


Fig. 3. Cyst width-frequency distributions of the naturally occurring *Alexandrium* cysts from Tokuyama Bay (upper) and Hiroshima Bay (lower).

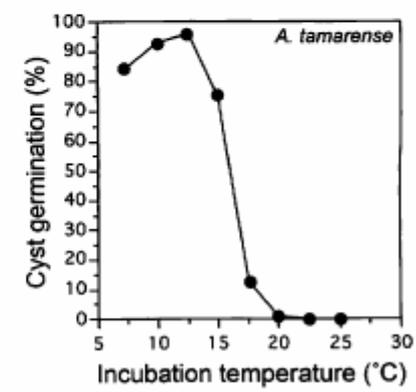
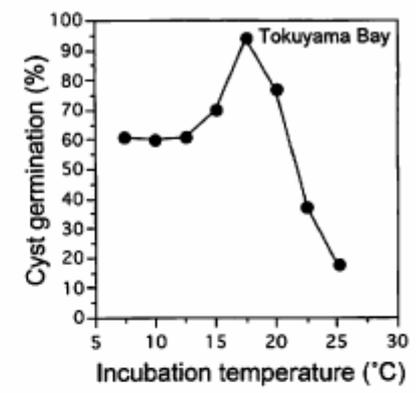


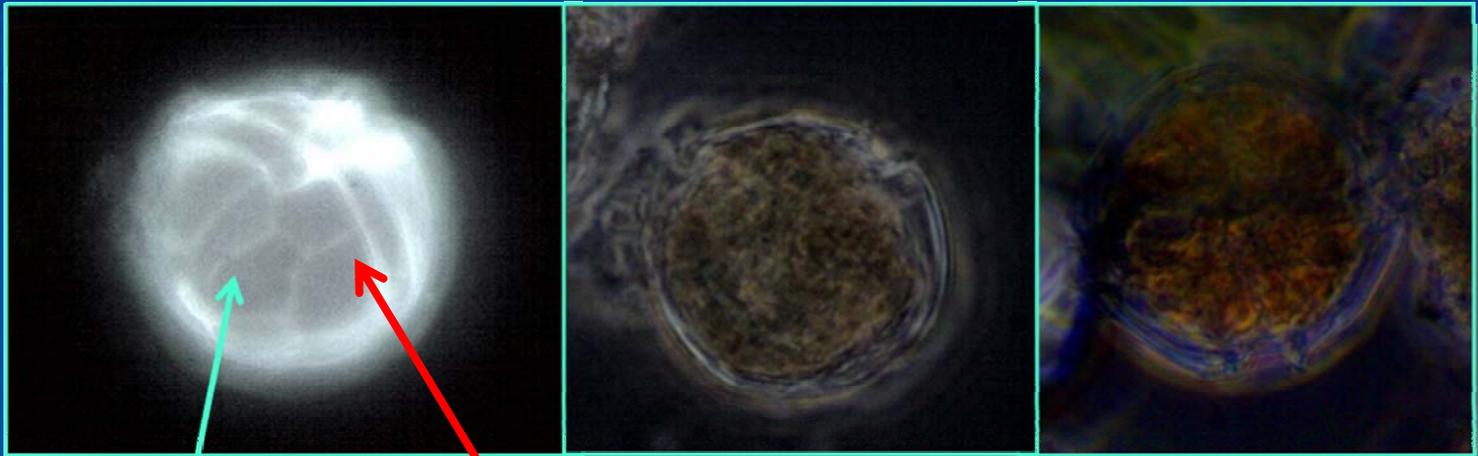
Fig. 4. Relationship between incubation temperature and germination success of naturally occurring *Alexandrium* cysts from Tokuyama Bay (upper) and laboratory produced *A. tamarense* cysts from Hiroshima Bay (lower).

(Itakura y Yamaguchi, 2005)



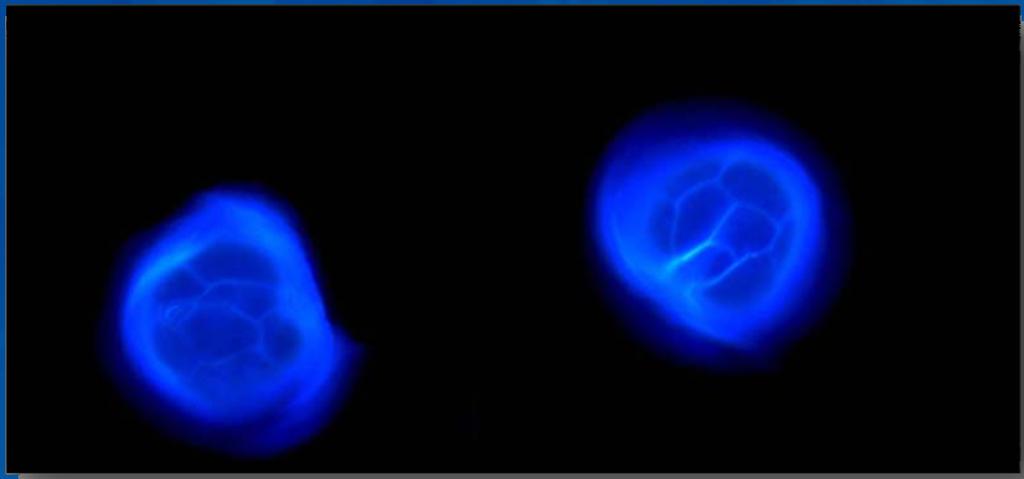
Alexandrium cf. tamarense

Detección en región de Los Lagos



Poro ventral

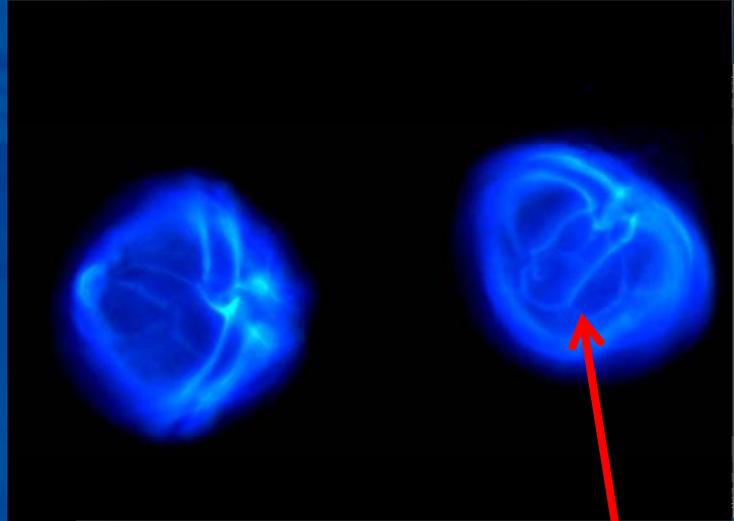
6''





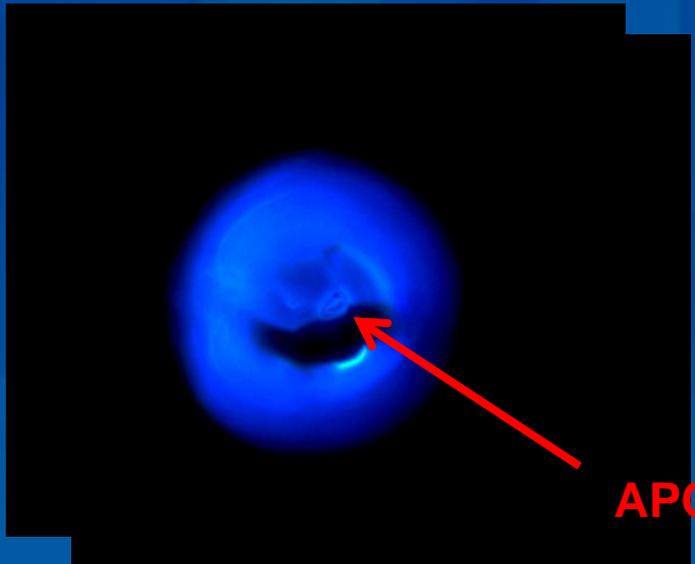
Alexandrium cf. tamarense

Detección en región de Los Lagos



Sp

(con o sin poro)



APC



Alexandrium cf. tamarense

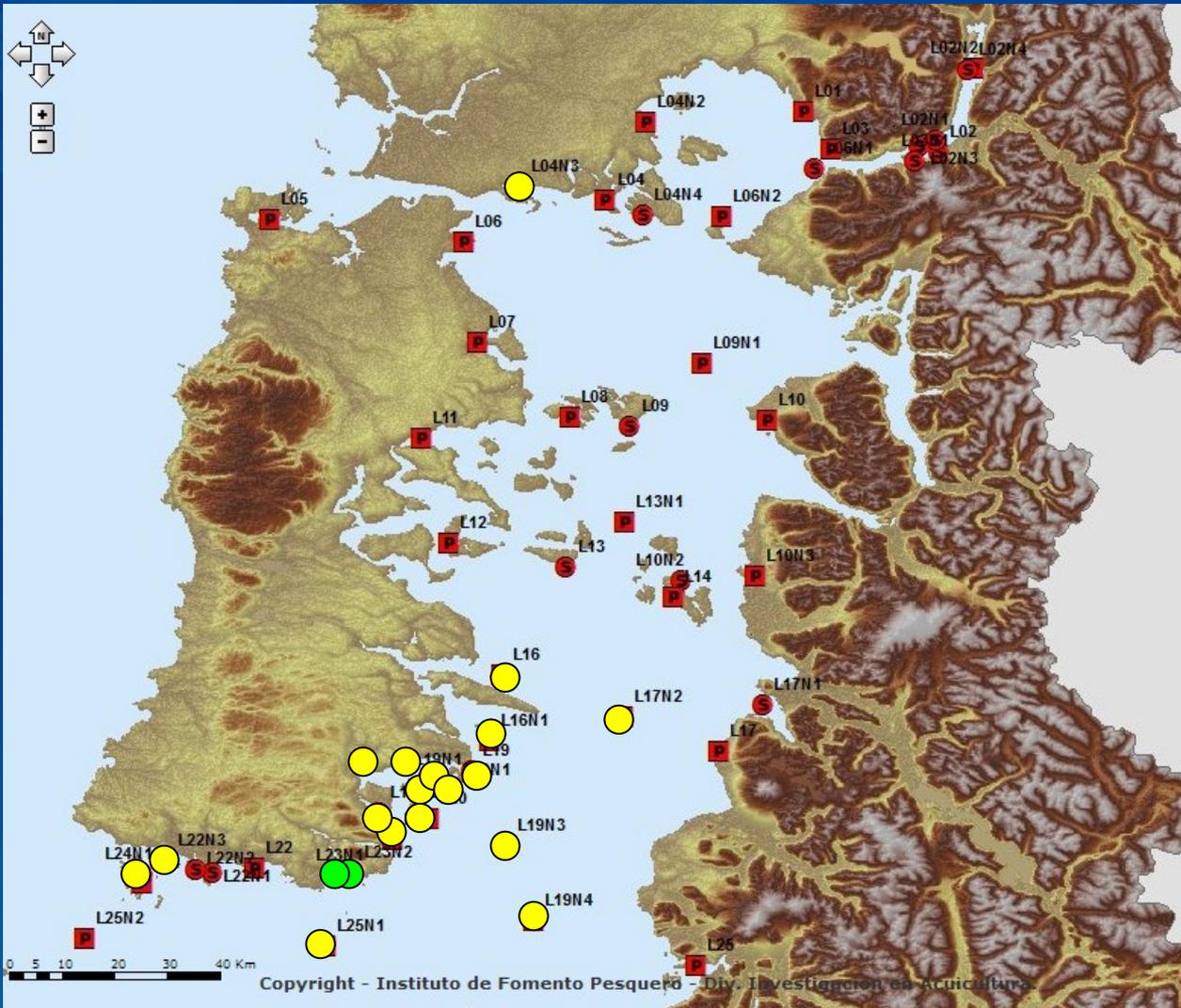
Detección en región de Los Lagos

Código	Estación	17 may - 3 jun 11	23 may - 8 jun 12	14 jun - 12 jul 12	5/jul/12	12 y 13-jul-12	24/jul/12	4 y 5-ago-12
L04N3	Chayahué	0	1	0	SM	SM	SM	SM
L16	I. Acui	0	1	1	SM	SM	SM	SM
L16N1	I. Chaullín	0	0	1	SM	SM	SM	SM
L17N2	I. Tranqui	0	0	1	SM	SM	SM	SM
L18	E. Yaldad	SM	SM	SM	0	0	0	1
L18N2	San Antonio	SM	SM	SM	0	1	1	1
L19	Pta. Chiguao	0	1	1	1	1	0	0
L19N1	Yelcho	0	0	1	1	1	1	1
L19N2	C. Coldita	0	0	1	0	0	1	1
L19N3	C. Coldita 2	SM	SM	SM	1	0	0	0
L19N4	G. Corcovado 2	0	0	1	SM	SM	SM	SM
L20	I. Laitec	0	1	1	0	1	0	0
L20N1	Bco. Velahue	0	1	1	1	1	0	0
L23	I. San Pedro	0	1	1	0	1	0	0
L23N1	C. Guamblad	1	1	0	SM	SM	SM	SM
L23N2	I. Sn. Pedro 2	1	1	1	SM	SM	SM	SM
L24	I. Guapiquillán	0	0	1	SM	SM	SM	SM
L24N1	I. Guapiquillán 2	0	0	1	SM	SM	SM	SM
L25N1	Boca Guafo	0	SM	1	SM	SM	SM	SM



Alexandrium cf. tamarense

Detección en región de Los Lagos





Género *Alexandrium*

Metodologías de análisis y detección

Uso de microscopía de epifluorescencia

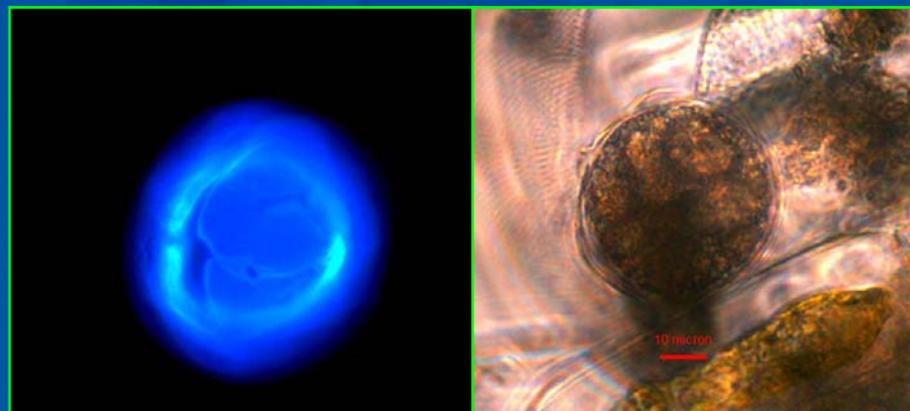
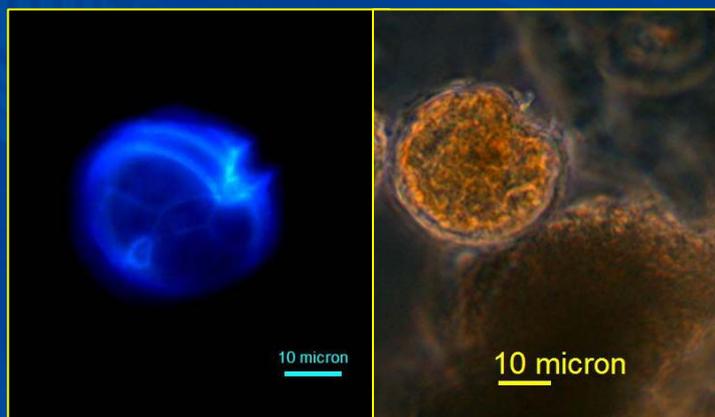
- Tinción Calcofluor o Fluorescent Brightener
- Filtro DAPI
- Uso recomendado para identificación de dinoflagelados tecados
- Mayor costo que microscopios convencionales
- Equipos adquiridos por Ifop y en uso desde 2009 (región de Los Lagos)



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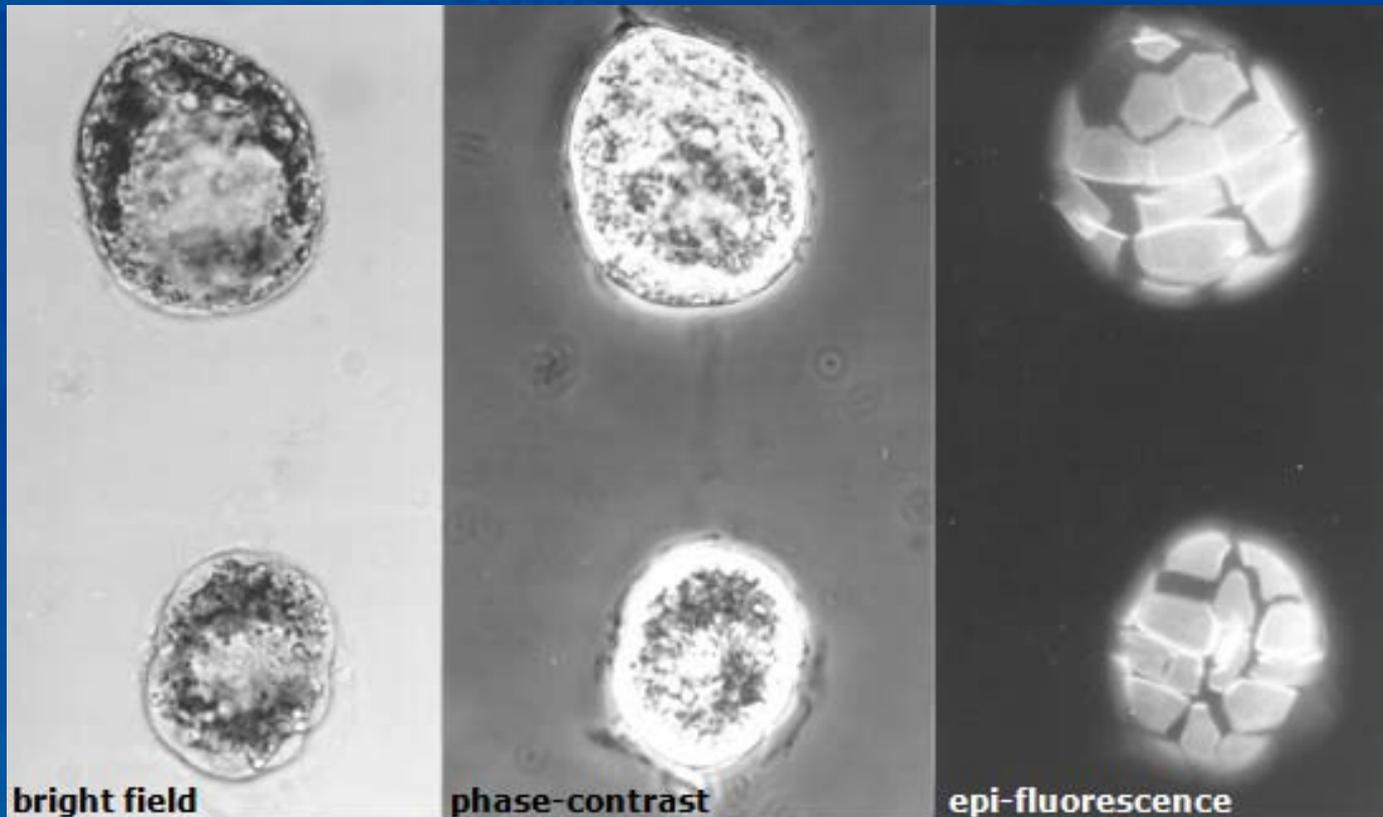




Género *Alexandrium*

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(Adaptado de Fraga, 2007)



Género *Alexandrium*

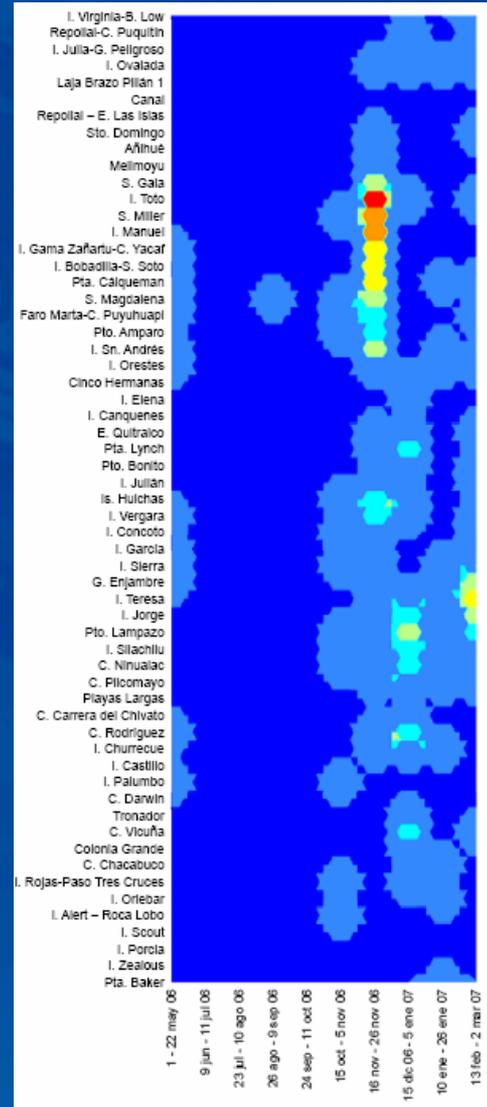
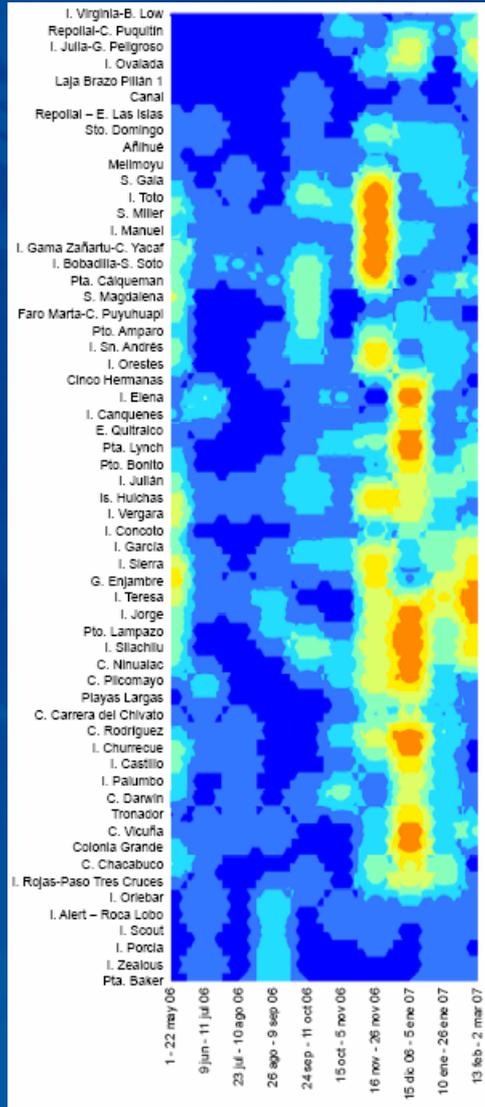
Metodologías de análisis y detección

Escalas de abundancia relativa para *Alexandrium*

	ESCALA	<i>A. ostenfeldii</i> , <i>A. cf. tamarense</i> (1)	<i>A. catenella</i> (2)
AUSENTE	0	0	0
RARO	1	1 - 5	1 - 2
ESCASO	2	6 - 15	3 - 10
REGULAR	3	16 - 35	11 - 42
ABUNDANTE	4	36 - 75	43 - 170
MUY ABUNDANTE	5	76 - 155	171 - 682
EXTREMADAMENTE ABUNDANTE	6	156 - 315	683 - 2730
HIPER ABUNDANTE	7	316 - 635	2731 - 10922
ULTRA ABUNDANTE	8	636 - 1275	10923 - 43690
MEGA ABUNDANTE	9	1276 - 2555	43691 - 174762



Abundancia relativa y densidad *Alexandrium catenella* Región Aysén. Período mayo 2006 – febrero 2007





Alexandrium tamarense

Tallado en madera por Dr. Haruyoshi Takayama

Símbolo de 12th International Conference
on Harmful Algae, Copenhagen, Denmark, 2006



Los Lagos

Leonardo Guzmán

Gastón Vidal

Ximena Vivanco

Victoria Arenas

Gissela Labra

Patricio Mejías

Mauricio Palma

Christian Espinoza

Nicole Pesse

Pedro Calabrano

Aysén

Luis Iriarte

Susana Mercado

Elías Fernández-Niño

Javier Monsalve

Raúl Hernández

Magallanes

Gemita Pizarro

César Alarcón

Hernán Pacheco

Pablo Salgado

Claudia Zamora

Cristian Garrido

Roberto Raimapo

Jorge Toro

MUCHAS GRACIAS